THUROW ON INFLATIONARY SPIRALS

Technology Review

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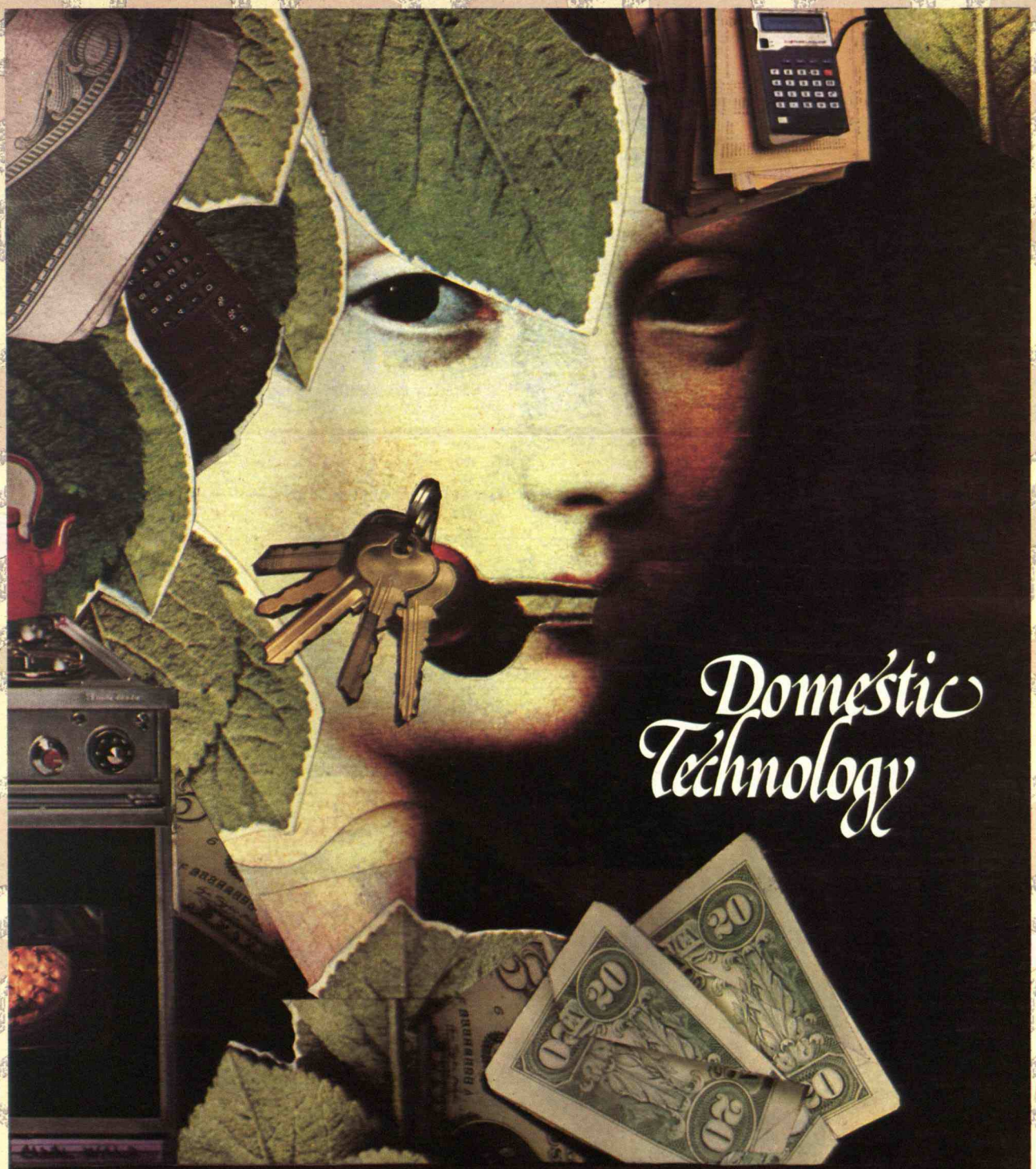

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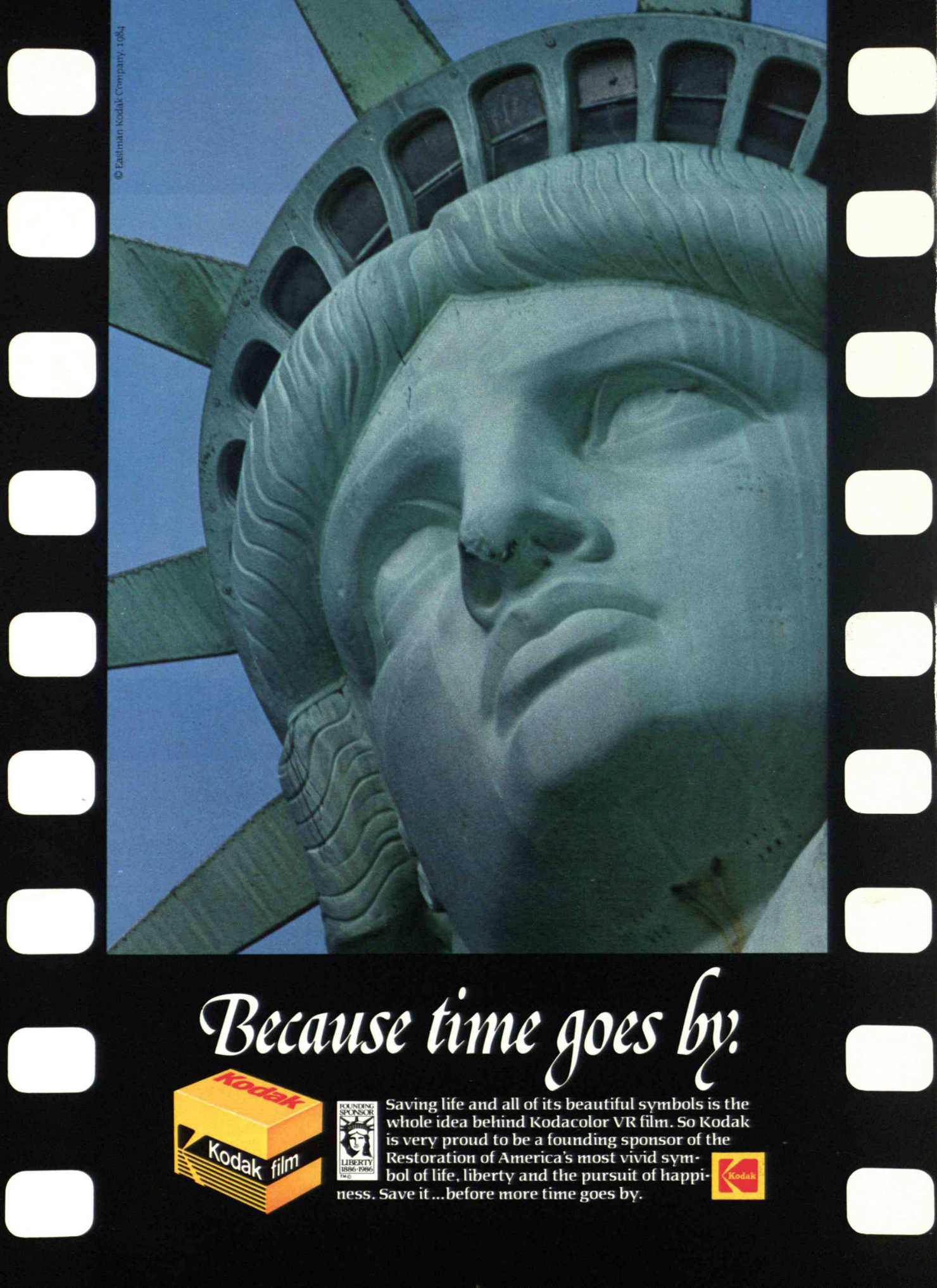
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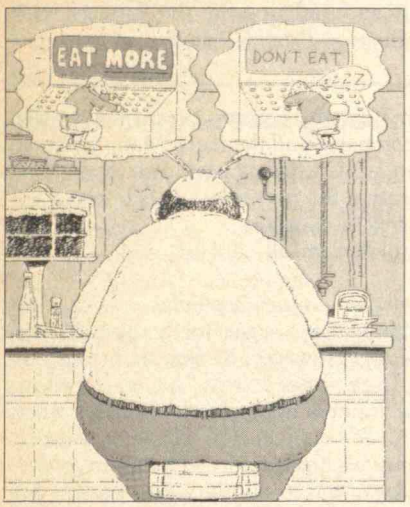

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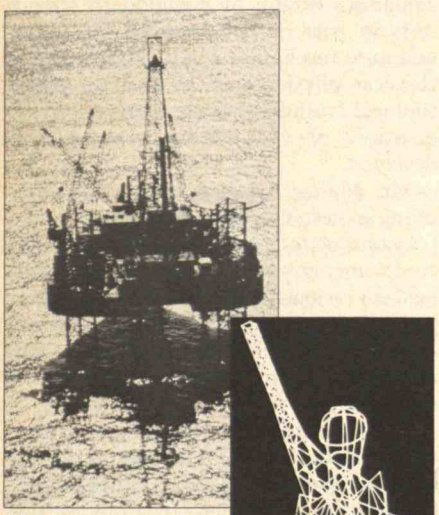

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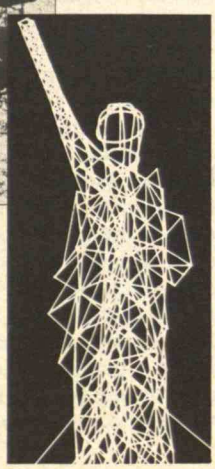

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Economic Expositor

Technology Review is delighted to welcome another new member to its fraternity of columnists. Lester C. Thurow, who is Gordon Y Billiard Professor of Management and Economics at M.I.T.'s Sloan School of Management, will write on economic affairs, particularly as they relate to technology, in alternate issues of the magazine.

With degrees from Williams College, Oxford, and Harvard, Professor Thurow has long been both an influential figure in setting public policies in the economic arena and a prominent expositor of economics for the general public. In addition to writing books such as *The Zero-Sum Society* and *Dangerous Currents: The State of Economics*, he has contributed regular articles to the *New York Times*, the *Boston Globe*, and the *Los Angeles Times*. Professor Thurow was also a regular columnist for *Newsweek* until early this year. His first contribution for the *Review*, on page 6, deals with cycles of recession and inflation in the modern U.S. economy.—*Peter Gwynne*

Scientific Cosmology

In his book *The Return to Cosmology*, Stephen Toulmin argues not against scientific cosmology but for it. However, in his review (*"Toward a Humanistic Cosmology," February/March, page 17*), David Layzer says that Toulmin contends that "science cannot make valid statements about the universe as a whole." Toulmin believes, as Layzer puts it, that the approaches of scientists and humanists "can be complementary, and even synergistic, instead of antagonistic." Perhaps Layzer has forgotten how recently the views he holds were not widely shared by scientists.
John R. Miles
Los Angeles, Calif.

Mr. Miles is an editor at the University of California Press, publisher of Toulmin's book.

Layzer makes a fundamental error in his description of religion. As a Christian, I am primarily concerned with my relationship with God, not with "a feeling of personal connection and harmony with the world."

God communicates by diverse means, including both scripture and nature. Science, on the other hand, deals only with information from the physical universe as it usually operates. Conflicts caused by science's limited approach are more apparent when one steps outside its specialties of description and prediction into evaluation (morality) and explanation (cosmology). Scripture has little to say about quantum mechanics, for example, but does say a great deal about the origin of the universe and humanity. Contradictions are better dealt with as the particle/wave problem of light was: by constructing a theory that encompassed *all* the facts. Many scientists who are Christians have little trouble integrating the two sides of their lives.
Darrell A. Martin
Carol Stream, Ill.

Professor Layzer responds:
Toulmin does argue for a scientific cosmology. However, by that he means cosmology based not on science as practitioners understand it but on a new kind of science: postmodern science. Hence his book's title, *The Return to Cosmology*, and its subtitle, *Postmodern Science and the Theology of Nature*. Toulmin's notion of postmodern science rests in part on the mistaken idea that quantum mechanics is less objective than classical physics, and in part on philosophical attitudes that are irrelevant to the questions of what science is and how it develops.

Mr. Martin raises a number of interesting issues. The view that science and a religious attitude toward the world can be complementary may or may not be widely held by scientists in our day, but it is hardly recent. Galileo, Kepler, Newton, Descartes, Leibnitz, Spinoza, and Kant, and before them Pythagoras and Plato, also held that view.

My characterization of religion's aims and attitudes was not meant to be exhaustive. However, I suspect that my notion of what constitutes a religious attitude toward the world is considerably broader than Mr. Martin's. Like William James and Albert Einstein, I believe that the essential ingredient in a religious outlook is feeling rather than belief. Theism—the belief in a personal god or gods who made and rule the world—is, in my opinion, neither necessary nor sufficient for a religious

attitude. Darwin's and Einstein's world views seem to me no less religious than Saint Augustine's.

That science "steps outside its specialties of description and prediction" when it tries to explain the world is a proposition that few creative scientists would find intelligible. Explaining the world is what science is about. The theories of Newton, Darwin, Einstein, and Friedmann, as well as the modern theories of quantum mechanics and of fundamental particles and their interactions, are all explanatory frameworks as well as systems for describing and predicting.

Doublethink and Doublespeak

Harlan Cleveland's "King Canute and the Information Resource" (*January, page 12*) is most perceptive and noteworthy. The Orwellian year 1984 already reveals many striking cases of "doublethink," or the holding of two contradictory beliefs simultaneously. Cleveland vividly highlights one such instance: the disastrous ramifications of "proprietary" concepts regarding the flow of information.

Other examples include:

☐ High-pitched anticommunist rhetoric and the relentless wooing of Communist China.

☐ Promotion of human rights and stepped-up aid to repressive dictatorships.

☐ Vast expenditures for defense and refusal to raise taxes to pay for them.

☐ Opposition to subsidies for "soft" energy sources such as solar but continued subsidies for nuclear power.

☐ Loud noises about the sanctity of the vote but shrieks of foul play when votes go against the interests of the United States, such as at the U.N.

☐ Promotion of the principle of balanced budgets and creation of mindboggling deficits.

Kris K. Murthy
Kingston, Jamaica

Harlan Cleveland comments that the name of King Canute "has gone down in history as a metaphor for futile efforts to avoid change." Actually, Canute sought not to avoid change but to cause it by imposing his will on a natural process. This is a particularly apt metaphor for the present age, which makes a habit of interfering in poorly understood natural processes, often with more serious results than wet feet. However, that analogy may not be the one Cleveland intended.

George Peabody
Halifax, Nova Scotia

Bumper Deregulation

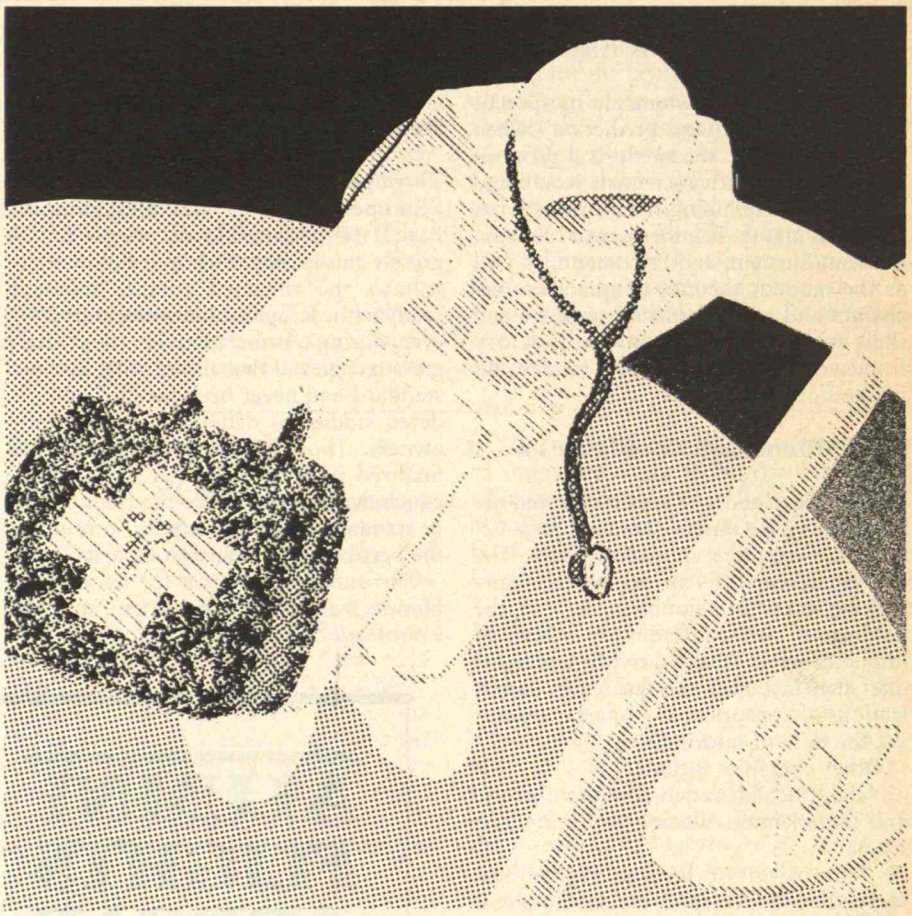
Through errors of fact and omission, "Bumper Strength: Will Deregulation Pay?" (*February/March, page 83*) is grossly misleading. Deborah Baldwin attributes the amended bumper standard solely to the Reagan administration. However, during a prior administration, Congress recognized that the existing bumper standard had never been justified and ordered studies to determine its appropriateness. Those studies, which were not finalized until after Reagan took office, concluded that the 5-mile-per-hour bumper standard was "not offering consumers the best possible reduction in costs."

The underlying reason for the original bumper standard was not safety, as stated

Continued on page 10

ROBERT C. COWEN

Doctoring Satellites: A Success Story



WHEN the "Ace Satellite Repair Co." aboard the shuttle fixed the Solar Max observatory in April, a new phase of space operations opened up. Frank Cepollina, mission manager representing Goddard Space Flight Center, may have overstated the case when he declared that the era of throwaway satellites was over. Communications satellites and other throwaways will continue to be used indefinitely. But for major scientific satellites and future unmanned space factories, the concept of in-orbit maintenance and reuse is the way to go.

The National Aeronautics and Space Administration (NASA) has made much of this repair capability, as it is a justification for the space shuttle system and space commercialization. Indeed, NASA's proposed space station—and hence the U.S. manned space flight program—would be of limited utility without it.

The Solar Max observatory takes its name from its original mission to study the sun during a period of sunspot maximum. Launched February 14, 1980, the satellite was supposed to have a life of two years. But after about ten months, three sealed fuses had failed in the attitude-control module. Solar Max lost its ability to orient itself precisely and, with it, the utility of four of its seven instruments.

The observatory is the first of the satellites designed for in-orbit maintenance. It has a grapple fixture to enable the shuttle's manipulator arm to grab it. However, NASA wanted to test a tactic for slowing down a spinning satellite prior to capture. So astronaut George Nelson flew to Solar Max using a manned maneuvering unit (MMU), or jet-propelled backpack; docked with the satellite; and tried to stop its slow spin. Unhappily, his effort set Solar Max spinning and wobbling so badly that the shuttle arm couldn't grab it.

Fortunately, Solar Max controllers at Goddard Space Flight Center were able to use the satellite's magnetic stabilizers, which interact with Earth's magnetic field, to kill the unwanted motion. The astronauts were then able to retrieve Solar Max, repair it, and return it to service. Astronauts Nelson and James van Hoften even replaced the electronics box of the satellite's Coronagraph/Polarimeter, which entailed opening up the satellite and closing the "wound" again. The renewed satellite has a nominal life expectancy of another two years but may well operate at least through 1988, according to Frank Cepollina.

This dramatically successful mission is seen as a key proof-of-concept with several levels of implication. To begin with, there is the rendezvous itself. No one doubted that the shuttle could link up with an orbiting satellite, yet it was important to demonstrate this in practice. Because a shuttle has limited propellant for maneuvering, it must approach a target in a way that minimizes propellant usage. This became critical when the first effort to retrieve Solar Max failed. For the second try, mission commander Robert Crippen skillfully adapted his piloting to cut propellant use well below that anticipated by the original approach procedures. This has given the shuttle team confidence in the spacecraft's ability to handle the many delicate rendezvous maneuvers that in-orbit service will require—to say nothing of building a space station.

The Case for MMUs

Mission officials say the astronauts also proved the feasibility of using the MMU to work with a satellite, as well as the practicality of grappling with the arm. They regard Nelson's failure to slow down Solar Max as a fluke. Many of the new satellites planned for shuttle servicing—such as the Hubble (space) telescope and a new gamma-ray observatory—can be grabbed directly by the shuttle arm. However, the ability to use the MMU to work in space will be important both in building a space station and in servicing the unmanned satellite platforms planned to accompany it.

Also, astronauts working with MMUs

ROBERT C. COWEN is science editor of the *Christian Science Monitor* and former president of the National Association of Science Writers.

ILLUSTRATION: TONY RICKETTS

The Solar-Max observatory is the first of the satellites designed for in-orbit maintenance.

would likely be needed if NASA were ever to retrieve Western Union's *Westar VI* and Indonesia's *PALAPA-B2*—both communications satellites. Having failed to reach geosynchronous orbit when their rocket boosters did not work properly after launch from the shuttle last February, the satellites are now in orbits that bring them within the shuttle's range. Lieutenant General James A. Abrahamson, former NASA associate administrator for space flight, has said that the Solar Max repair "gives a great deal of confidence" in the satellite-recovery concept and confirms studies NASA has been making of how to retrieve the satellites. General Abrahamson—now director of U.S. strategic defense—noted that NASA can't go after the "lost" satellites without requests from their owners. But NASA hopes the owners will make their decision "with our [Solar Max] success . . . in mind."

Although NASA was not responsible for the failed booster rockets, retrieving those satellites would be a dramatic display of shuttle prowess. So too would be the repair of a failure for which NASA is responsible—that of the *Landsat 4* satellite. Launched July 16, 1982, it has lost power from two of its four solar panels, and its x-band radio transmitter has also failed. Although a replacement satellite is now in orbit, NASA would like to repair *Landsat 4* and refuel the hydrazine propulsion module used periodically to adjust its orbit. Success with the tricky refueling would be especially significant. However, this operation will have to wait a couple of years until the shuttle launch facility at Vandenberg Air Force Base in California is ready. *Landsat 4* is in polar orbit and can be reached only from that launchpad.

The adventure with Solar Max overshadowed another part of the April mission that showed the shuttle's ability to manipulate heavy, bulky objects with delicate precision. This was deployment of the LDEF, or Long Duration Exposure Facility. Some 30 feet by 14 feet (the size of a school bus) and having a mass of 21,600 pounds, it is the largest, most massive object shuttle astronauts have handled. LDEF has no attitude-control system; it is stabilized vertically by gravity. The astronauts had to place it in orbit so that it was oriented correctly and had no residual spin or wobble.

LDEF is the first of what may become a fleet of passive satellites that can carry experiments intended to take advantage of the space environment. LDEF carries 57 experiments designed to, among other things, expose electronic materials, capture micrometeorites, and grow plant seeds (including some 13.5 million tomato seeds). When the shuttle returns LDEP to Earth next year, the seeds will be distributed to 130,000 classrooms around the United States. By growing these in school projects, millions of children will share in research designed to look for any significant difference between the space plants and control seedlings sprouted on Earth.

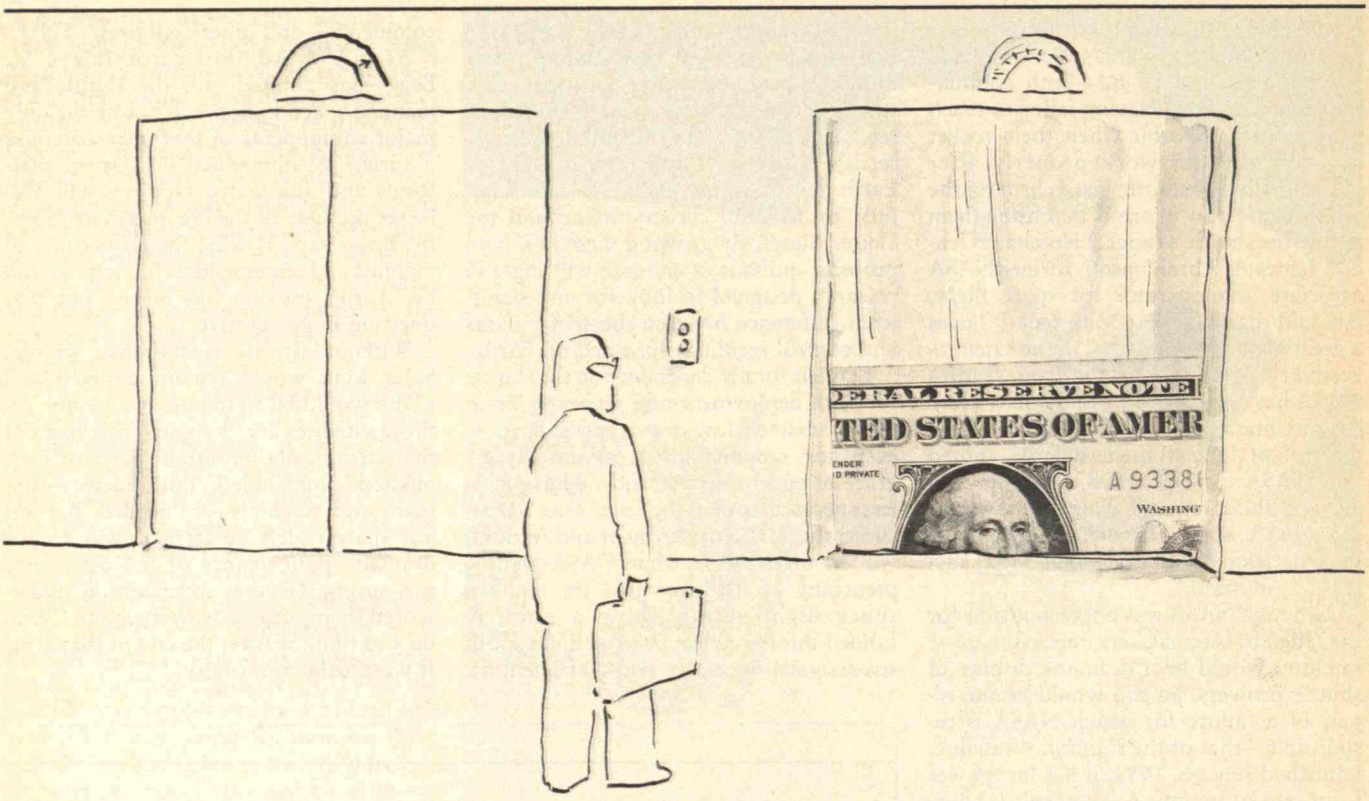
LDEF is totally dependent on the shuttle for both deployment and retrieval. Yet it offers relatively low-cost access to space—even for schoolchildren, admittedly by grace of government subsidy. Thus, while less spectacular than the Solar Max repair, successful LDEF deployment and retrieval will fit nicely with what NASA is now preaching as its main goal for manned space flight—establishing a publicly funded infrastructure to make near-Earth space available for a variety of scientific, commercial, and other civil uses.

As NASA Administrator James M. Beggs has pointed out, the shuttle and manned space station will not be the only major components of that infrastructure; a variety of unmanned instrument platforms and automated factories will also be set up. One of the big questions to settle, Beggs says, is what the proper mix of manned and unmanned technology should be. April's mission has helped put that question in perspective.

Without astronauts and their shuttle, Solar Max would remain crippled and LDEF would be an impossible dream. Yet those satellites are "happily" carrying out the scientifically important parts of their missions unattended. Both factors—humans and machine—are needed. But lest any space cadets be carried away by the dramatic performance of the astronauts this spring, General Abrahamson underscored their purpose with the quip: "Who do you think was on the end of that arm? It wasn't the tooth fairy." □

LESTER C. THUROW

Preventing the Eleventh Recession



THE United States is currently enjoying a recovery from its tenth recession since World War II. Given our history of repeated economic relapses, the eleventh recession is obviously just a matter of timing. To put recessions behind us, or even to reduce their frequency, structural changes are required in the U.S. economy. Yet in the euphoria of the current recovery, the necessary changes aren't even being discussed. We would rather pretend that somehow this recovery is going to be permanent.

America's ten recessions can be divided into two groups. The first five, ending in the recession of 1960-61, all occurred by accident. They sometimes resulted from government actions, such as cutbacks in Defense Department expenditures after World War II and the Korean War, but policymakers were not trying to cause the recessions. And in each case, the government immediately rushed to the rescue with Keynesian pump priming—lower taxes, higher spending, easier money.

The next five recessions were deliberately caused by government policymakers. Inflationary shocks—such as the Vietnam War, the Russian grain deal and the corn blight, and the two OPEC oil price hikes—hit the economy. Inflation then broke out and reached unacceptable levels. Not knowing what else to do, policymakers stepped on their fiscal and monetary brakes to stop the economy. Unemployment rose, and when it got high enough, it forced inflation out of the economy. And in each cycle, the beating that the economy endured before inflation moderated grew larger and larger.

The most recent cycle of recession and recovery has been no different. The economy took a repeated and prolonged beating between 1979 and 1982. Housing and autos were the hardest hit, but for almost four years there was no net growth in the GNP. Unemployment reached levels unseen since the Great Depression. Yet in the first quarter of 1984, the consumer price index was already rising at a 5 percent annual rate. That looks good relative to the 13.5 percent inflation rate of 1980, but it is dismally high for this early in a recovery from a deep, prolonged recession. The cyclical upward ratcheting of inflation and unemployment is still with us.

LESTER C. THUROW is Gordon Y Billiard Professor of Management and Economics at the Sloan School of Management at M.I.T.

A Double-Digit Shock

There is also another inflationary shock—a falling dollar—looming on the horizon. The United States imports almost 10 percent of its GNP. If the dollar were to fall by 50 percent, the price of imports and goods competing with imports would rise, generating an inflationary shock comparable to that of either OPEC oil price hike. When combined with the present underlying rate of inflation, such a shock would put us right back in double-digit inflation.

We know that the dollar is doomed to fall even if U.S. interest rates stay high. Our balance-of-trade deficit is already running at an annual rate in excess of $120 billion per year. No nation can run such a deficit for long. Such deficits have to be

ILLUSTRATION: MICHAEL CRAWFORD

financed with foreign borrowing, and at some point other countries will decide that they have lent enough of their assets to the United States and that they do not want to increase the proportion held in dollar loans. At this point the lending will end and the dollar will fall. We also know that if the dollar is overvalued by 30 percent (the standard estimate), it will overshoot and fall by more — for that is the history of flexible exchange rates in the last decade. A 50 percent drop in a currency overvalued by 30 percent would not be at all surprising.

What is unknown is the timing of such a drop. No one knows or can know when the dollar will fall, for that is a matter of psychology. Each day nervous treasurers of multinational companies compare the gains they make from higher U.S. interest rates with the losses they will incur if the dollar falls. Each treasurer of a German company, for example, knows that if he moves 300 million marks into the United States when the exchange rate is 3 marks to the dollar, his $100 million in American investments will return only 200 million marks when the exchange rate has fallen to 2 marks to the dollar. Such losses easily wipe out all of the gains from higher interest rates and often get corporate treasurers fired. Each treasurer wants to be in dollars earning those higher interest rates but also wants to be the first person out of the dollar when the drop begins. As a result, the fall of the dollar is apt to be very rapid once it starts.

And when the downward spiral in the value of the dollar begins, inflation is likely to break out and become unacceptable. Policymakers will once again tighten monetary policies, pushing the economy into its eleventh recession. The time to restructure the economy to make it less inflation-prone is not when inflation arrives—by then it is too late—but before the inflationary shock arrives. What has to be done is clear.

When the dollar falls, the United States suffers what economists call a deterioration in terms of trade. Since the price of imports has gone up, it now takes a larger volume of exports to buy the same volume of imports. This means that after we pay for the imports that we need, fewer goods and services are left over to be divided among Americans. During the second OPEC oil shock in 1979, for instance, Americans' bill for imported oil rose from 2 to 5 percent of the GNP. The result is a reduction in the U.S. standard of living.

The reduced standard of living can occur in two ways. If we want a noninflationary economy, U.S. incomes must go down in parallel with the decreased volume of goods and services left to be divided among Americans. Or, if we refuse to accept a cut in our incomes, prices must rise to balance the purchasing power of those uncut incomes with a lower available volume of goods and services. Either way, our real standard of living is reduced. However, if prices do increase, the losses are magnified by the recession induced to stop the resulting inflation.

Matching Income to Trade

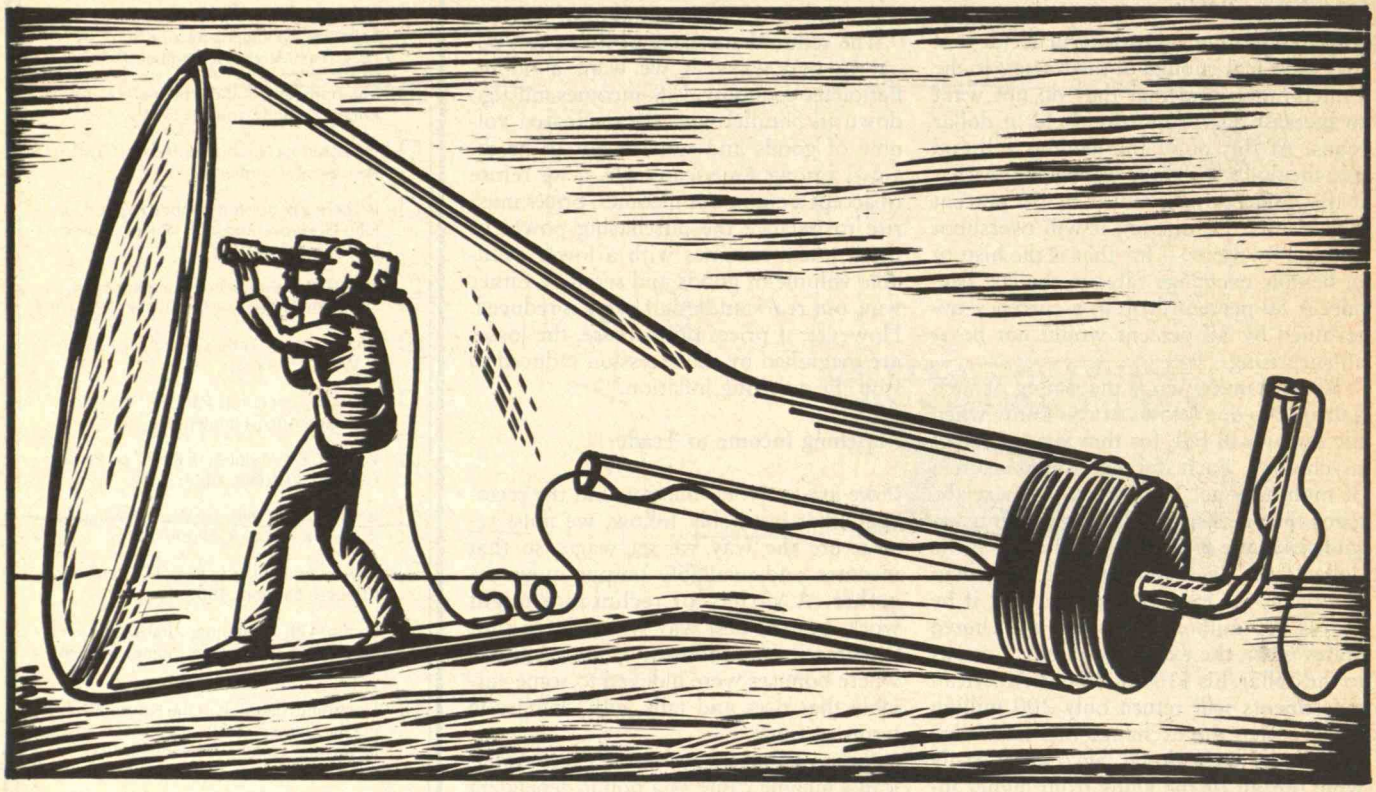
If we are to avoid inflation and the recessions that inevitably follow, we must restructure the way we set wages so that incomes and available output move together. A variety of techniques might work, but the best way would be to shift the American economy to a bonus system, where bonuses were indexed to some variable that rises and falls with changes in terms of trade.

Suppose that 20 percent of every American's income came as a bonus dependent upon value added per hour of work. Because value added is basically the difference between sales revenue and the cost of materials purchased, higher prices for imported raw materials and components would automatically lead to a lower value added. That, in turn, would lead to smaller bonuses and a cut in everyone's income. We could easily shift the economy to this kind of indexed bonus system by enacting a tax law that excuses bonuses from payroll taxes up to some limit, say 20 percent of total wages or salaries. With such a system, individuals and corporations who refuse to shift to the bonus system would find themselves paying higher taxes than their competitors.

The problem is not how we disentangle the economy from boom-and-bust cycles, but whether we are willing to do what we have to do. Unfortunately, at the moment, we Americans are pretending that the problem doesn't really exist. As the U.S. economy is now structured, full employment cannot exist without inflation for any length of time. Yet despite our history of failure in this area, we choose to pretend that the tenth recovery is somehow different and is not going to be quickly followed by the eleventh recession. □

BY FRED JEROME

Science News: Breaking the Silence Barrier



EACH morning's paper and each evening's TV news seem to bring a new report on a deadly danger in our food, water, or air. EDB is just the latest in the growing toxic alphabet that began with DDT and includes DDD, DDE, PCB, DBCP, 2,4,5-T, and dioxin. We aren't really sure what these chemicals will do to us, but the media use the term "cancer-causing," and we are worried. If we live in areas directly affected, we are downright terrified.

Concerned about mounting public alarm, an increasing number of scientists and engineers has accused the media of using scare tactics. While nearly all agree that serious environmental hazards do exist, many scientists and engineers charge the media with equating all dangers, oversimplifying the science and technology involved, and sensationalizing the risks. Says Edward Burger, director of the Institute of Health Policy Analysis at Georgetown University Medical Center, "The press emphasizes the simplistic and the scary."

FRED JEROME is director of the Media Resource Service, a program of the Scientists' Institute for Public Information in New York.

Accounts of media distortions abound within the scientific community, especially in the areas of nuclear power and toxic chemicals. For example, last October the *Toronto Globe & Mail* reported that nuclear-fuel debris at one of the Three Mile Island reactors "poses a threat of atomic explosion"—a technological impossibility. And a few months earlier, when a transformer of Commonwealth Electric Co. on Cape Cod leaked some PCB fluid, a Boston newspaper headlined the story: "Crowd Showered by Deadly PCB Gas." The PCBs, however, were neither deadly nor gaseous.

Indeed, to protest such distortions, some scientists have decided to refuse to talk to the press. But by boycotting all the media, they are ignoring a growing corps of competent, careful science journalists.

During the recent EDB controversy, for instance, the *San Francisco Chronicle* ran a story by its science editor David Perlman under the headline "Dangers of EDB to Human Health Still Unknown." Perlman's lead stated: "Scientists researching the health effects of the toxic chemical known as EDB agree the bromine compound is one of the 'nastiest' cancer-causing substances in the environment—but still have no idea at what levels it can pose a hazard to human health." The article continued in the same vein for a thousand words or so, quoting several leading scientists in and out of government, and was accompanied by a carefully prepared glossary of the most frequently headlined acronyms from EPA through PCB. A similar story by *New York Times* science writer Philip Boffey was headlined "Experts Are Split on Pesticide Risk." While scare stories may sell more papers, both these articles emphasized uncertainty, and uncertainty, in this case as so often in science, is the fact.

The Easy Scapegoat

No one, least of all members of the press, denies that poor reporting, sensationalism, and distortion exist. But good reporting also occurs, and the media's critics would have a stronger case if they acknowledged that fact. In fact, Dr. Francis Moore, professor emeritus of surgery at Harvard Medical School, has compared U.S. press coverage of science with that of other countries and believes U.S. media do a "more conscientious job of accurate re-

ILLUSTRATION: ANTHONY RUSSO

In "blaming the messenger for the bad news," scientists and engineers are guilty of the same kind of exaggeration they fault the media for.

porting." Moore, who heads the book-review section of the *New England Journal of Medicine*, suggests that critics of the U.S. media take a look at the British press, which he calls "hopelessly sensationalist."

Moreover, when critics imply that there would be no problem if only the media would go away, what they are really doing is "blaming the messenger for the bad news." And in doing so, they are often guilty of the same kind of exaggeration they fault the media for. When polls commissioned by the Atomic Industrial Forum showed that the public opposed building more nuclear plants by 2 to 1, a spokesperson for the pronuclear group blamed saturation coverage of nuclear plant mishaps since Three Mile Island. An even more extreme example of blaming the messenger occurred in a front-page editorial in Dow Chemical's house organ, *The Point Is . . .*, of October 7, 1980: "If there is any 'poisoning' of America going on, it's not chemicals that are the culprit. . . . It is the media, which all too often seems intent on burying us in piles of purple prose—a sort of verbal poison."

However, the media did not create the accident at TMI (despite the *National Enquirer's* page-one headline, "Nuclear Plant Accident a Hoax!"), nor did the media put the dioxin in the ground at Times Beach. As none other than Alexander Haig said on ABC's "Nightline" last fall, "The basic problem (in Vietnam) was not bad press but bad policy. I think our democracy gets into trouble when we confuse the two." Media coverage may indeed be flawed, but without it we would lose one of our society's strongest assets.

Science coverage has expanded dramatically in recent years, particularly in the print media. At least seven major new science and technology magazines were launched between 1979 and 1982 to cater to what publishers perceived to be a growing popular interest in the field. Although some of these magazines have folded in the last year or so, the survivors appear to be doing very well. Even more significantly, no fewer than 14 large and mid-sized newspapers have launched weekly science sections during the past two years, with more on the way. While the quality of science coverage varies from paper to paper, the new sections all share the goal of making science and technology understandable to the general, non-science-sophisticated public. This coverage represents a major departure from most science publications, which are aimed at what has been called the "science-attentive" audience.

Who's Really to Blame?

But despite the increased number of daily newspaper pages devoted to science and technology, most of the stories that appear in print are written by reporters who do not consider science their "beat." Most media outlets do not have their own science specialists, either because they cannot afford them (as is the case with many small newspapers) or because those in positions of editorial power do not perceive the need for them. Many top-ranking newspaper editors, having won their own spurs as political or investigative reporters, are much more likely to hire reporters with expertise in political or investigative journalism than in science writing.

Furthermore, science and technology have become so interwoven with our daily lives that most breaking science-related stories are part of other newsbeats. Was the dioxin spill at Times Beach a science story or national news? And who was assigned to cover Reagan's "Star Wars" speech? In most cases, it was a political reporter with little or no science background. Have we, then, found our culprit at last? Is it the political or general-assignment reporter, usually untutored in science, covering issues he or she knows little about?

No doubt, many of these reporters deserve part of the blame for what Bob Cowen, science editor of the *Christian Science Monitor*, calls "the fluff that often passes for science journalism." But for all their serious weaknesses, these journalists for the most part report what they are told—usually by official sources.

It was not the media but New York Health Commissioner Robert Whelan who, in 1978, announced that Love Canal posed "a great and imminent peril." It was not the media but New Jersey Governor Thomas Kean who ordered the evacuation of the Ironbound neighborhood of Newark after dioxin traces had been found in the soil. And it was none other than the EPA Administrator Anne Gorsuch Burford who ordered the evacuation of Times Beach, Mo., on February 22, 1983. If the headlines are unwarranted, more often than not they are based on announcements from officials, or at least from prestigious scientists or scientific groups.

If anything, most reporters are guilty not of being too critical but of not being critical enough. They tend to accept what their official sources tell them, and they rarely seek out additional sources who might provide them with more accurate information or a different perspective.

"The real problem is a bias for big organizations, including and especially the government," says Associated Press reporter Lee Mitgang. "Unfortunately, the media place higher credibility on Department of Energy figures than on those of independent scientists." Cornell Professor Dorothy Nelkin, a board member of the Council for the Advancement of Science Writing, says that far from being overly negative about science, most science writers tend to glamorize it: "While newspapers employ critics of art, theater, music, and literature, science is by and large spared from this critical approach."

But exaggerated praise and alarmism are simply two sides of the same uncritical coin. When journalists don't question, they can't analyze, and scientific developments are reported like the girl with the curl—either all good or all bad. The ordinary reader or viewer begins to feel like a ping-pong ball batted between the equally painful paddles of exaggerated hope and sensationalized fear.

The Roundtable Approach

One possible reason many reporters don't ask more questions is that they don't know where to turn. Ask the average nonscience reporter what his or her biggest problem is in covering science and technology and, ten-to-one, the answer will be: finding reliable sources of expert information. At three recent science workshops for general-assignment reporters in Pennsylvania, Sharon Friedman, journalism professor at Lehigh University, reports that most of the participants "cited lack of background and information sources as their chief problem in covering these topics."

If this is the problem, then scientists and engineers can definitely assist in the solution. But first they must discard the "gone-fishing" approach to journalism. ("If that reporter calls, tell him I've gone fishing.") They should also remember that most journalists are operating under tight deadlines, so returning their calls a week late is not going to be of much help.

Fortunately, more than 15,000 scien-

Continued on page 77

Continued from page 3

by Baldwin, but rather increasing insurance costs. However, regulators used the Motor Vehicle Safety Act to justify the standard because they lacked the authority to pass a bumper standard on the basis of cost savings. Later, when Congress passed the Motor Vehicle Information and Cost Saving Act, the bumper standard was relabeled a cost-saving standard.

Though Baldwin attributes auto industry support of the lower standard only to its effect on sticker price, the industry's analysis included lifetime fuel usage, levels of collision damage, and insurance costs. The insurance industry—not the auto industry—insists on basing its arguments on only part of the total cost-benefit picture.

Baldwin cites a Ford Motor Co. study of dents in cars in parking lots as the "chief basis for the Reagan administration's move." The public docket on this matter indicates that Ford supplied information from that study at the request of NHTSA long before the current administration took office. When NHTSA finalized further research, it replaced the Ford study in the agency's cost-benefit analysis.

Finally, the author states that "no auto manufacturer has claimed a price drop owing to less sophisticated bumpers." General Motors announced an $8 across-the-board reduction on precisely this basis for 1983.

DeWayne A. Landwehr
Warren, Mich.

The writer is a member of the General Motors Corp. Environmental Activities Staff. The author responds:

Mr. Landwehr mischaracterizes the process by which the bumper standard was weakened. The standard was changed by Reagan administration officials in the name of cutting auto-industry regulation. The final NHTSA analysis is the official justification for the change but cannot be viewed in isolation. In fact, two previous administrations, those of Gerald Ford and Jimmy Carter, announced they were studying the possibility of weakening the standard and gathered material that supported a change. However, only the Reagan administration actually concluded that the standard should be changed and then went on to do so.

Insurance studies completed since the bumper standard was weakened suggest that this administration's studies were simply wrong in their prediction of consumer savings under the weaker standard.

Mr. Landwehr does not appear to dispute my contention that the first 5-mile-per-hour bumper standard was issued primarily on safety grounds—the only grounds allowed under the Motor Vehicle Safety Act. That legislation did not require a study but rather only an administrative decision showing that stronger bumpers would improve auto safety.

NHTSA analyst Barry Felrice, who actually performed the cost-benefit analysis of the two standards, told me that the Ford parking-lot study tipped the balance to the 2.5-mile-per-hour standard.

Finally, I regret that GM's $8 price decrease was not reported to me by NHTSA and the Motor Vehicle Manufacturers Association, the sources for my statement that no manufacturer claimed a price drop due to the lower standard.

Risk Regulation

In "Discarding the Double Standard in Risk Regulation" (*January, page 10*), Peter Huber makes a novel distinction: between "setting standards" for old risks and "screening" for new risks. His solution—"comparative regulation, with a flat focus on risk and risk alone"—leaves open the question of the value of risk-benefit analysis. Should benefit be disregarded, or perhaps considered as part of the assumption that most technologies "are substitutes, not additions?"

Bruce A. Lacy
Campbell, Calif.

The author responds:

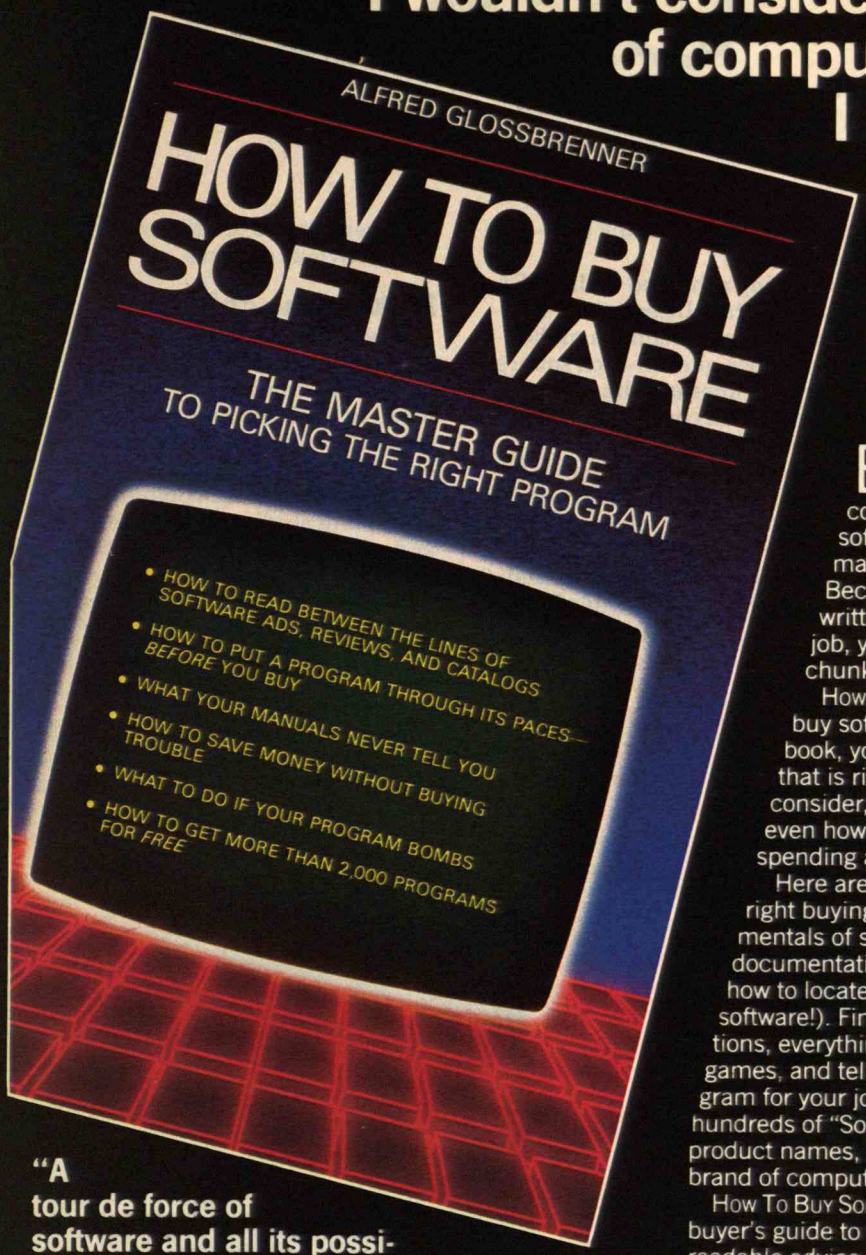
Comparative risk regulation need not displace risk-benefit analysis. It provides a more manageable administrative tool in many situations. Quantifying benefits is extremely difficult—more so than quantifying and comparing risks. The most important advantage of comparative regulation is that it allows regulators to take some shortcuts when the need for particular benefits has already been accepted owing to popular demand or political pressure.

Comparative regulation simply looks for the safest means of achieving a certain benefit. Risk-benefit analysis takes on the larger task of determining whether the price of additional safety is worthwhile. The drawback of comparative regulation is that some products will be tolerated (or

Continued on page 77

"I wouldn't consider buying a piece of computer software until I read this book."

—Peter A. McWilliams, author of *The Personal Computer Book* and *The Word Processing Book*



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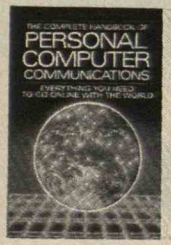

Also by Alfred Glossbrenner:
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Alfred Glossbrenner is a communications consultant and professional writer based in Bucks County, Pennsylvania. This is his ninth book.

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Cracking

Summary:

Microelectronics is a major force behind the information age. It permits faster information processing through packing more and more components on a chip. GTE scientists have developed methods of producing advanced VLSI chips with 1.2μm feature size. The next stage is 0.8μm, and further reductions are on the way.

The ability of today's microelectronics to process information lags behind industry's need to transmit it.

GTE is working on this problem both by increasing data-handling capability, and by reducing data-processing time.

This is being achieved with VLSI (Very Large-Scale Integration) system densities approaching a million components per quarter-inch square, with reaction times in subnanoseconds, and with computer-aided design.

GTE scientists are developing advanced compiling systems for the full hierarchical design of more and more complex integrated circuits. They have also developed gate-level and functional-level circuit simulators that were five to ten times faster than previous systems.

Making the chip.

The computer is also put to work in the chip manufacturing process. It directs the lithography, level by level, as well as other processes such as selective etching of deposited materials by ionized gases.

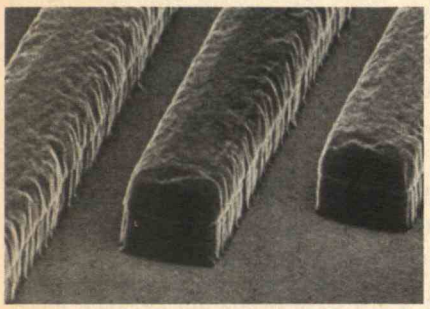
Currently, we are completing pilot-plant studies of a 1.2μm process and will transfer it to production facilities.

But feature dimensions continue to shrink. When they were comfortably above the wave length of visible light, it was possible to use light waves for precise lithography.

As the 1.0μm dimension is approached and passed, however, defi-

the 1 μm barrier.

nition begins to blur, and other techniques are needed. Among these is electron-beam lithography, with sub-micron resolution.



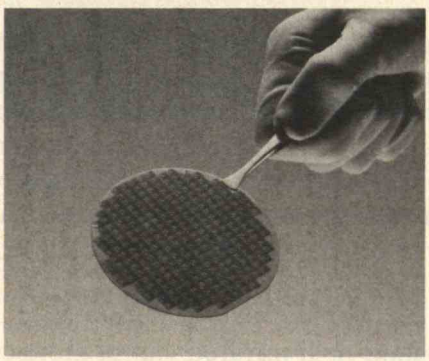
We are now working in the 0.8μm dimension. And we have identified experimental devices of 0.5μm and below as our next targets. (This dimension range begins to approach the distance an electron travels in solids before it scatters. By the time it has a collision, it has performed its work. Imagine the speed and precision this signifies.)

VLSI tomorrow.

Shrinking feature size to submicron dimensions is only part of the story. Other ongoing work in our laboratories includes replacing silicon as the chip matrix with faster-acting gallium arsenide, and building up the chip with epitaxial-film deposition, layer by layer.

Such VLSI research is helping accelerate the evolution of more sophisticated microprocessors, "burst" switching, PABX-on-a-chip, high-speed digital technology, and more.

In the box at the right is a partial list of pertinent papers by GTE people on VLSI and related subjects. For any of these, you are invited to write GTE Marketing Services Center, Department TPIC, 70 Empire Drive, West Seneca, NY 14224.



Pertinent Papers.

End Point Detection for Reactive Ion Etching of Aluminum, J. Electrochem. Soc., 1984.

Highly Selective Dry Etching of Polysilicon Using Chlorinated Gas Mixtures for VLSI Applications, Electrochemical Society Meeting, May 6-11, 1984.

Negative Resistance Switching in Near-Perfect Crystalline Silicon Film Resistors, 30th American Vacuum Society Symposium, November, 1983.

Vertical, Dual-Gate CMOS NAND in Two Laser-Recrystallized Silicon Layers over Oxidized Silicon Substrate, Materials Research Society Spring Meeting, February, 1984.

Reactive Sputter Etching of Single Crystalline Silicon, Proceedings of 3rd Annual Symposium on Plasma Processing and Extended Abstracts 83-1, 163 Electrochemical Society Meeting, May, 1983.

Reactive-Ion Etching of Single Crystalline Silicon with $Cl_2 + SiCl_4$, Proceedings of Fourth Conference on Plasma Processing, Electrochemical Society Meeting, May, 1983.

GTE

SCIENCE/SCOPE

NASA's Project Galileo may provide clues to the origins of the solar system when it explores the planet Jupiter later this decade. Project Galileo is scheduled to be launched from the space shuttle in May 1986 and arrive at the giant planet in August 1988. The mission consists of two spacecraft. One is an orbiter that will circle Jupiter for 20 months. The other is a Hughes Aircraft Company-built probe that will plunge into the planet's brightly colored clouds and relay data about the atmosphere. The probe is expected to operate for about 50 minutes before succumbing to temperatures of thousands of degrees, limited battery capacity, and pressures up to 10 times that of Earth's at sea level. Because some scientists believe that Jupiter's atmosphere is a sample of the original material from which stars are formed, the probe's findings will be closely studied.

Residents in central Indiana are the first in the U.S. to receive television programs in their homes broadcast directly from a satellite. Last November, United Satellite Communications Inc. began the first direct broadcasting satellite (DBS) transmissions to homes in 33 counties surrounding Indianapolis. Transmissions were relayed via Anik C2, designed and built by Hughes for Telesat of Canada. Homes receive the signals through antenna dishes that are less than three feet in diameter and sell for about $300. The more familiar satellite receiving dishes found in rural areas of the U.S. average four to five feet in diameter and sell for more than $2,000. Initial programming includes two satellite movie channels and the ESPN sports network.

A network of small "smart" radios will let U.S. troops and their commanders know where they and friendly forces are located at all times. With the Position Location Reporting System (PLRS), combat troops will no longer have to seek landmarks to pinpoint their location. PLRS automatically supplies position and navigation data in digital form through a computerized communications network that displays data on a small hand-held box. PLRS units can be mounted on vehicles, aircraft, and helicopters. All units serve as automatic relay stations, so that units far away from a master station can stay in touch regardless of terrain or weather. Hughes is producing PLRS for the U.S. Army and Marine Corps.

Thermoelectric cooling has made a hand-held infrared viewer more convenient and more economical. The Hughes Probeye™ infrared viewer, originally equipped with argon gas cooling, now comes in an all-electric model. The new version weighs 1.2 pounds less and makes sustained use easier and less tiring. The Probeye viewer sees heat the way a camera sees light, converting it instantly into an image seen through an eyepiece. The viewer is used to spot heat maintenance problems and energy losses in industrial and commercial applications.

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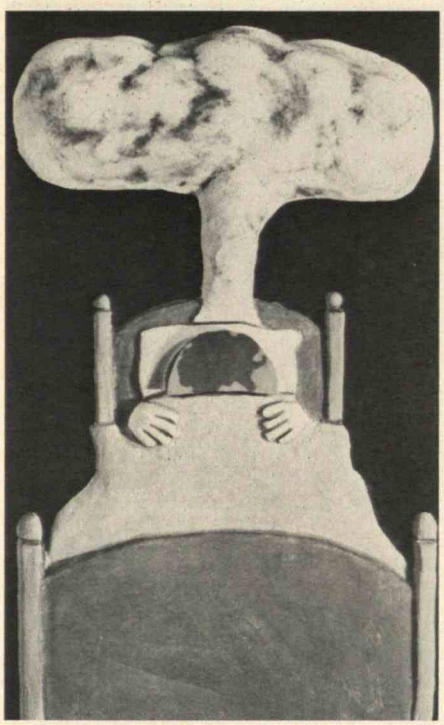
HUGHES
AIRCRAFT COMPANY

Nuclear Nightmares, Injury Epidemics

Third World Nuclear Nightmares

The First Nuclear World War
by Patrick O'Heffernan, Amory Lovins, and L. Hunter Lovins
Morrow Books, $17.95

Reviewed by Gerald M. Steinberg



Some observers expect that a nuclear war will start in Europe after a conventional war between the superpowers has grown out of hand. However, as the world's inventories of plutonium and enriched uranium increase, the knowledge of how to use these materials to manufacture nuclear weapons is becoming available to many states and terrorist groups. Thus, in *The First Nuclear World War*, Patrick O'Heffernan, Amory Lovins, and L. Hunter Lovins predict that Third World countries and the terrorists they sponsor will trigger a nuclear conflagration. To make their case, the authors devise a fictional scenario showing how such a war might develop, give a history of the proliferation of nuclear weapons, and present a prescription for arresting this self-inflicted cancer.

Unfortunately, the authors' first effort—to create a plausible scenario for a nuclear war originating in the Third World—is weak. Their story begins in 1985 with terrorists dispatching a sample of plutonium, accompanied by an ultimatum, to the U.S. and Israeli governments. After their demands are rejected, the terrorists—including a professor of physics at the University of California-Berkeley, a Pakistani postdoc, and an American PLO sympathizer—detonate three nuclear weapons. The first, planted at a nuclear power reactor in California, causes 14,000 deaths. The second, an atomic artillery shell stolen from the U.S. arsenal in Europe, explodes in Israel, killing 40,000 people. The third bomb, placed in downtown Chicago, fails to go off. When the perpetrators are traced to Pakistan, Israel attempts to retaliate with the cooperation of India and the Soviet Union. A nuclear war between India and Pakistan ensues in which hundreds of thousands of people die. After a brief respite, Iraq and Iran exchange nuclear blows, and eventually oil wells in Saudi Arabia and Kuwait are also hit.

This sequence of events strains the reader's credibility, as cooperation among Israel, India, and the Soviet Union is politically inconceivable. Also, if a bomb were detonated "just over the border with Jordan," as the authors hypothesize, thousands of the casualties would be Palestinians and other Arabs, and no PLO group, no matter how deranged, would likely kill so many of its own. The authors further speculate that the terrorists would use small, supposedly unsophisticated nuclear bombs. However, the less the nuclear material available, the more difficult detonating a nuclear weapon becomes. Thus, many test explosions would be needed to make an effective miniature nuclear bomb.

For readers able to move past such technical inaccuracies, the second section clearly shows the link between nuclear power and nuclear weapons in the Third World. The authors point out that the United States gave countries such as India, Pakistan, Brazil, and Iran their first practical experience with nuclear materials by eagerly providing "civilian" nuclear reactors through the Atoms for Peace program. These reactors actually enabled these countries to manufacture nuclear weapons.

Indeed, Canada, France, and Italy competed with the United States to sell or give away nuclear facilities and train their operators. As nuclear power programs in the developed world were cut back and the industry came close to bankruptcy, it was able to win Third World contracts by agreeing to supply facilities useful for making weapons. For example, West Germany provided uranium-enrichment and fuel-reprocessing equipment along with large power reactors to Brazil. These sweeteners not only gave that country the ability to manufacture bomb-grade material; they also enabled Brazil to sell such materials to other states such as Iraq.

Some observers argue that the International Atomic Energy Agency mitigates the potential for abuse of nuclear facilities in the Third World. The IAEA oversees a system of safeguards designed to prevent civilian nuclear programs from being used to manufacture bombs. Yet these restrictions do not apply to some nuclear facilities in countries such as India, Pakistan, Israel, and Argentina that operate outside the IAEA framework. And even where the IAEA safeguards do apply, they have been largely ineffective. For example, Iraq progressed nicely in its ability to manufacture a bomb until Israel destroyed the Iraqi facilities in 1981—the attack a clear vote of no-confidence in the IAEA system.

As the authors note, Third World states and terrorist groups could also acquire nuclear weapons by stealing them from U.S. bases in Europe, which store thousands of nuclear land mines, artillery shells, and other tactical nulcear weapons. Guard duty at these installations is tedious, and drug use and alcoholism are common among the soldiers. Indeed, in one terrorist attack on a U.S. base in Germany, only a few German guards with police dogs stood between the attackers and 16 nuclear weapons. And enough conventional weapons such as rocket launchers have already been stolen from bases in Europe to equip ten combat divisions.

What can be done about this dangerous state of affairs? The authors of *The First Nuclear World War* recommend that the illusory nature of the safeguards provided by the IAEA and other international organizations be exposed. As was the case with the former U.S. Atomic Energy Commission, the IAEA safeguards have become a mere ancillary aspect to the agency's effort to promote nuclear power. The authors propose that the IAEA separate into independent promotional and regulatory units, as the AEC was divided into the Nuclear Regulatory Commission and the Department of Energy.

ILLUSTRATIONS: KEN GOLDSTROM

Eight million Americans alive today can expect to die from injuries.

In the long term, the authors would end the development of nuclear power in both the Third World and the industrialized world. As they point out, the investment in nuclear energy is irrational for many developing countries. Iraq has a large petroleum supply, and Pakistan does not need the large-scale centralized nuclear power plants it is building. Civilian nuclear power in these countries simply provides a thin facade for a nuclear weapons program. The authors also urge that the United States, Europe, and Japan set an example and help curb the dangers of nuclear weapons proliferation by pursuing the "soft energy path"—including solar energy, biomass, and conservation.

However, as inviting as this prescription sounds, the case is not convincing. The feasibility of the soft path is still uncertain, and the recipe for Third World countries is politically naive. Iraq, Pakistan, and India are not going to give up their nuclear power programs voluntarily. In Pakistan, the former president became a hero for declaring that his country would build a nuclear weapon even if "the people had to eat grass." In India, Indira Ghandi's detonation of a nuclear weapon in 1974 won her millions of votes in the following election.

The nuclear Pandora's box cannot be closed. Instead of pursuing such an unrealistic vision, we should begin with more feasible steps. First, the United States could tighten security on nuclear weapons and technology in Europe—or even remove them entirely. Second, all nations should end the production and sale of plutonium. The United States has already taken an important step by cutting back its breeder reactor program; we should encourage our European allies to do the same. After all, it is France, Italy, and West Germany—not the United States—that have been selling the most dangerous nuclear facilities to Third World countries.

Those who are concerned about limiting the proliferation of nuclear weapons must realize that, as with negotiating arms-control agreements between the superpowers, the obstacles are many and the path is long. Several small steps grounded in technical and political realities rather than naive quick fixes present the best opportunity for progress. □

Gerald M. Steinberg teaches science and technology policy at Hebrew University in Jerusalem.

The Preventable Epidemic

Injuries
by Leon Robertson
Lexington Books, $25

The Injury Fact Book
by Susan P. Baker, Brian O'Neill, and Ronald S. Karpf
Lexington Books, $25

Reviewed by Daniel V. Edson

There exists today a fervor for eliminating heart disease, cancer, and stroke, the three leading causes of death in the United States. Each well-publicized breakthrough stirs anew hope for that elusive cure. Paradoxically, finding a way to prevent personal injury, the fourth leading cause of death, does not excite nearly as much interest. More than 160,000 Americans died from injuries in 1980—53,000 from motor-vehicle crashes alone—yet no one has vowed to find a cure in our lifetime. Most people consider safety an afterthought rather than a habit, and injuries events to be expected rather than prevented. Ironically, many injuries could be prevented, or at least lessened in severity, at an acceptable cost with state-of-the-art technology. Yet the public, manufacturers, and government are not oriented toward making safety as important as health.

The impact of injuries on our lives, and our society's odd way of dealing with them, are the subjects of these two definitive works. Easily read and quite complementary, the books provide the first comprehensive assessment of injury cause, effect, and policy. Robertson, in the Department of Epidemiology and Public Health at Yale, thoroughly reviews the causes of injuries, various control strategies, and the cost to society. Baker, of the Johns Hopkins School of Hygiene and Public Health, and O'Neill and Karpf, of the Insurance Institute for Highway Safety, analyze mortality figures to reveal the socioeconomic trends and misconceptions regarding injury-related fatalities.

According to the authors, injuries are the leading cause of death for persons under age 45, and motor-vehicle-related injuries are the leading killer among people under 35. Most people can expect to suffer a significant injury at some point, and almost everyone will have a relative or friend killed or permanently disabled by injury. In fact, 8 million Americans alive today can expect to die from injuries.

Public-health officials have traditionally relied heavily on education and persuasion to inform the public about how to prevent injury. Mock auto crashes teach TV viewers the value of seatbelts, and government-printed pamphlets tell consumers how to handle combustibles safely. But as the authors of *Injuries* and *The Injury Fact Book* make clear, education has not changed people's behavior significantly. Only 10 to 15 percent of automobile passengers wear seatbelts, for example, even though a much larger percentage is aware of the benefits of doing so. The ineffectiveness of education is doubly frightening because research has shown that individuals who are high injury risks are also those least likely to protect themselves. For example, high-risk drivers—teenagers, speeders, tailgaters, and drunk drivers—also tend not to wear seatbelts.

This correlation raises the question of whether people must be protected from themselves. Must passive restraints—automatic seatbelts or airbags—be provided when seatbelts requiring active use are already mandated? Most enlightened public-health workers feel that if all the reasonably priced safety devices available are not provided, then society is in effect condemning high-risk individuals to in-

jury or death. Yet without public pressure, neither industry nor government will treat safety problems aggressively. Federal agencies such as the Consumer Product Safety Commission and the Occupational Safety and Health Administration are underfunded and hampered by bureaucratic delays and lengthy court battles with industry over new regulations.

Though safety devices and design improvements are not always cheap, the cost to society for the extraordinary injury rate is high. The loss of productivity and medical costs owing to injury total more than $25 billion yearly. Thus, although people may push government to regulate manufacturers because of altruism and a fondness for their own lives, the bottom line benefits from this effort as well.

The authors of both books analyze injuries by reducing them to their various components. These include a cause, usually termed an *agent*; a means of transfer, termed *vehicle* for inanimate objects and *vector* for animate carriers; and a *host*, or person injured. Injuries can be prevented or ameliorated by affecting one of these aspects, through either voluntary or involuntary action. Voluntary efforts might include users' buying drugs with child-proof caps or manufacturers' restricting sales of concealable handguns. Involuntary actions stem from regulations aimed at either users (all motorcyclists must wear helmets) or causes (airbags must be standard equipment in automobiles). Because U.S. constitutional guarantees make restricting individual behavior difficult, regulatory agencies concerned with safety usually target manufacturers.

The authors point out that public-health officials too often focus on only one way to prevent an injury. For example, cities can reduce gun-related injuries by restricting handgun sales, but they can also do so by improving the lighting around 24-hour stores and protecting gas-station cashiers with bullet-proof shields.

Injuries and *The Injury Fact Book* will not change overnight society's tendency to take for granted burns, falls, bruises, broken bones, poisoning, and highway slaughter, nor will they alter human nature. But they should create an awareness of injuries that fosters an openminded, broad-based approach to prevention. □

Daniel V. Edson, a science and technology writer based in Cambridge, Mass., was formerly associate editor of Design News.

· THE 1984 ROLEX AWA

CONCERN FOR THE ENVIRONMENT IS HIGHLIGHTED

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Each of the five winners, announced in Geneva on 26th April 1984, has received 50,000 Swiss Francs. Also, each winner has been presented with a specially inscribed gold Rolex Chronometer, itself a symbol of enterprise and achievement.

REINTRODUCING GRIFFON VULTURES TO FRANCE

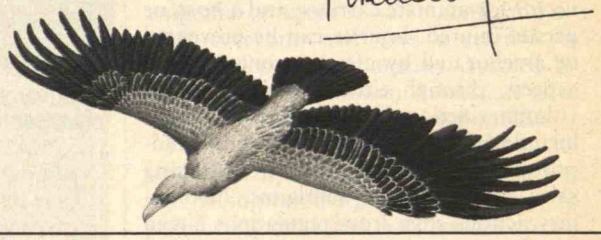
Between 1920 and 1940 guns and poison successfully and systematically wiped out the magnificent Griffon Vulture from the Massif Central area of France.

French biochemist Michel Terrasse has committed himself passionately to redressing the balance of nature, by reintroducing this impressive bird of prey to the Cevennes.

The Griffon Vulture, despite its wingspan of 2.8 metres, is harmless to man. In fact, these birds had been a valuable asset to French sheepherders there. Feeding only on dead animals, they rid the land of carcasses, thus saving shepherds the time and expense of burying dead livestock.

So far, Michel Terrasse, after much effort and patience, has succeeded in repopulating the area with a colony of 30 vultures, and in recording the births of two young vultures—the first to be born free in the area for 50 years.

Ecologists and ornithologists watch the work of Michel Terrasse with interest. His Rolex Award for Enterprise will help him with his fascinating programme of repopulation.



PLANTING ASPARAGUS TO PREVENT SOIL EROSION

Three years ago, Mr. Thean Soo Tee realised the opportunity of cultivating asparagus in the Mt. Kinabalu area of his native Malaysia, some 1,200 metres above sea level. Asparagus grows well and quickly on this irrigated land, reaching maturity nine months after sowing.

The enormous root system of the asparagus plant, set firmly by permanent cultivation, would hold back the soil and save the sloping fields from erosion.

With existing crops of cabbage, peas, carrots, etc., the earth must be turned over after each harvest for the next cropping cycle, exposing it to attack by wind and water, which turn it ultimately into stone-strewn, unproductive land.

Mr. Tee also recognised that, as asparagus fetches a higher price in the market-place, its cultivation would substantially increase the income of the local farmers.

Encouraged by early success, Mr. Tee plans to develop five model farms where the local farmers could work and learn the cultivation techniques necessary and then, hopefully, abandon their traditional system for permanent agriculture.

A careful evaluation of European and American species of asparagus is also planned with a view to providing a wider genetic base for the asparagus development programme in Malaysia.

For its originality and endeavour, Mr. Tee's project has earned a Rolex Award for Enterprise.

RDS FOR ENTERPRISE ·

AN EXPLORATION OF BRABANT ISLAND IN ANTARCTICA

A specially picked team of men is currently over-wintering on Brabant Island—an island as yet unsurveyed.

It is the intention of Kenneth W. Hankinson, an Englishman, to ensure that a thorough study of the island will be made. A study which will yield a geological history of this gateway to the Bransfield and Gerlache Straits.

Flora and fauna will be studied to assess ecological balance and likely future development on the island.

In particular, a close study will be made of a seal species which feeds on planktonic shellfish. The major peaks will be scaled. The land mass charted. And the first circumnavigation of the island effected by canoe.

Throughout the entire stay, under canvas, a close observation will be kept on the psychological effect that close confinement, intense study and almost continual darkness and danger will have on the behaviour of individual team members.

The 1984 Rolex Award for Enterprise he won will help Kenneth Hankinson and his expedition to achieve their aim: putting Brabant Island comprehensively on the map.

K.W. Hankinson

EXAMINING THE TROPICAL FOREST CANOPY

The upper layer of tropical rain forest is one of the last unexplored frontiers known to man. This "canopy" is the home of several million species of plants and animals, most of which are still unknown to scientists.

A no-man's land between earth and sky. Its branches are too thin, too flexible, to bear the weight of eager research biologists.

Donald Perry, an American biologist, whose project is planned for Costa Rica, however, has devised an ingenious "spider's web" which can be suspended from the taller trees in order to carry a harness from a secure observation platform.

Biologists may thus study life processes, pollination, fruit bearing, etc., in relative safety.

As tropical rain forest is being cut down at an alarming rate, a Rolex Award for Enterprise couldn't have come at a better time for Donald Perry's project.

Donald R. Perry

AN INVENTORY OF ALL THE MAYAN WALL PAINTINGS

Eight years ago, Martine Fettweis-Vienot, a determined and dauntless Belgian archaeologist, decided to take on the gigantic task of compiling the first inventory of Mayan wall paintings.

The last remnants of Mayan culture, which flourished between the 3rd and 15th centuries, are to be found in ruined temples and cities soon to crumble and disappear forever.

Mme. Fettweis-Vienot is reproducing the work done between the 7th and 15th centuries. Each painting must be traced on cellophane paper directly from the wall or ceiling. Every single one must be transferred with immense precision. Each colour intensity must be accurately reproduced.

Mme. Fettweis-Vienot then intends to analyse the constituents of the Mayan colours in special laboratories.

Her Rolex Award for Enterprise will help towards the completion of this important iconographic study.

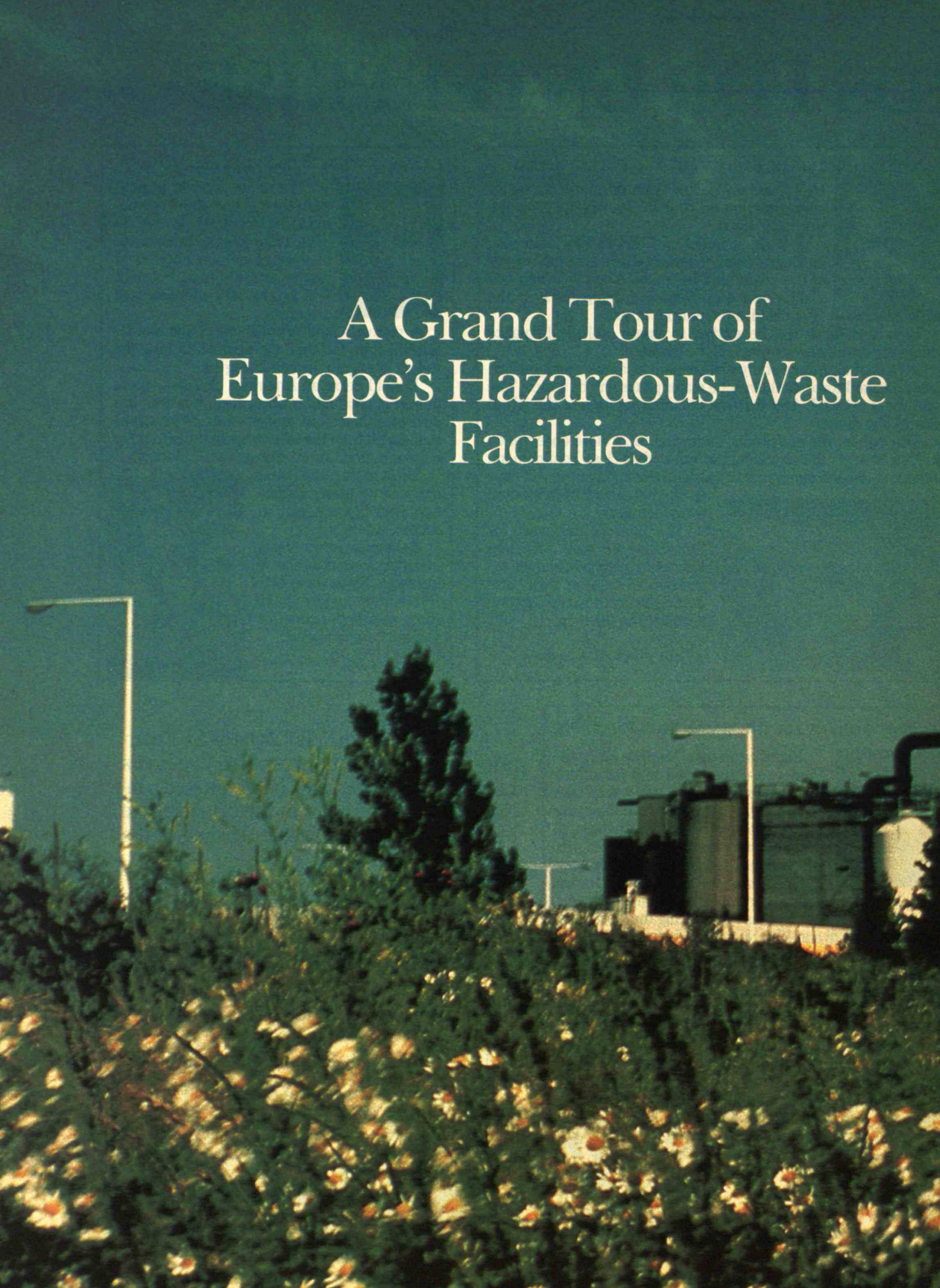
M. Vienot

A book about the Rolex Awards for Enterprise, detailing the projects of the five Rolex Laureates and over 200 other projects, including the 26 winners in the "Honourable Mention" category, will be published in the Spring of 1984.

Further information is available from:
The Secretariat,
The Rolex Awards for Enterprise,
P.O. Box 178, 1211 Geneva 26,
Switzerland.

ROLEX
of Geneva

A Grand Tour of Europe's Hazardous-Waste Facilities



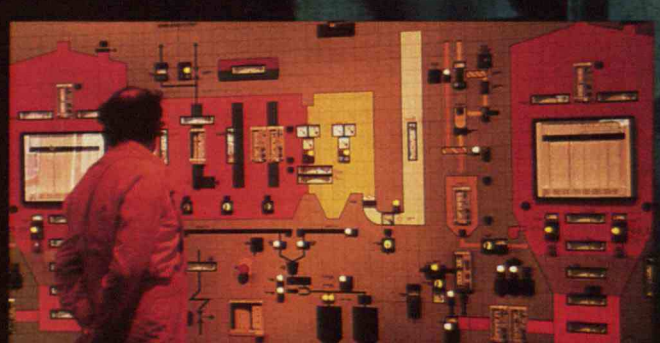
WHILE debate rages in the United States about what to do with the 150 million tons of hazardous chemical wastes generated in the country each year, several industrialized nations in Europe are quietly recycling and destroying their toxic wastes. The hazardous-waste facilities in these countries resemble chemical plants rather than the leaking landfills that litter America. Their successful operation indicates that America's uphill battle to clean and contain thousands of leaking toxic dumps, pits, ponds, and industrial lagoons represents an expensive trip down the wrong road. Land disposal will always pose a considerable threat to public health and a nation's drinking water, but safe altneratives to landfills already exist.

Over ten years ago, land-conscious Europeans decided that dumping chemical garbage on or into the ground is neither safe nor economical. Instead, several countries developed management systems designed to reduce the amount of toxic wastes generated and use modern chemical technologies and high-temperature incinerators to recycle

BY BRUCE PIASECKI AND GARY A. DAVIS

Using a combination of new technology and sophisticated political management, European nations have avoided many of the pitfalls encountered by the United States in dealing with toxic wastes.

The Danes come to braise their toxic wastes, not to bury them. Replacing problem-plagued landfills, the Kommunekemi treatment facility detoxifies and destroys 60,000 tons of hazardous waste annually.



Operated by a space-age control panel (left), the EBS facility outside Vienna will burn and treat Austria's toxic wastes. Still to come is a comprehensive regulatory system to ensure the facility's use.

Washington's emphasis on securing toxic landfills for future dumping appears profoundly inconsistent with our longstanding leadership in technology.

waste and minimize the need for dumping. Although most forms of waste treatment produce small quantities of residues that must be disposed of in secured—that is, leakproof—sites, the net result is that the risk, waste volume, and overall costs to both society and its leading firms are greatly reduced.

This approach involves more than sophisticated technology. Governments in the Old World realize that reliable new techniques are essential for getting rid of wastes, but they also recognize the need for effective public policies to introduce and use those techniques rationally. The result, in several European countries, has been a creative combination of private and public enterprise that manages toxic wastes with a minimum of expense and red tape. The techniques have not avoided local protests entirely, but these incidents have not approached the scale of U.S. demonstrations against waste dumps.

A handful of forward-looking U.S. firms has struggled to put waste reduction, recycling, and advanced treatment technologies to work in this country. However, in contrast to the Europeans, the U.S. government has actually discouraged the use of these practices by favoring continued land disposal.

The European Example

Before dismissing the European techniques as more lead-into-gold fantasies that just won't work at home, consider these comparisons: While 80 to 90 percent of the hazardous wastes generated in the United States are still dumped directly into landfills or land-based facilities, 60 percent of West Germany's toxic wastes are detoxified instead of dumped. In Denmark, where 98 percent of the nation's drinking water comes from groundwater, virtually no untreated chemical wastes are disposed of on land. Instead, treatment technologies destroy or detoxify practically all of that country's most threatening wastes.

West Germany and Denmark lead the way in waste management. Yet other European countries are now designing chemical waste facilities that minimize, or aggressively phase out, land disposal of toxic pollutants. Sweden and Finland are borrowing heavily from the Danish example by constructing centralized high-tech treatment centers. Austria has a shining new centralized incineration and treatment facility, and is now developing a comprehensive regulatory scheme that will insure its use. In the Netherlands, the Chemical Waste Act of 1979 explicitly prohibited the dumping of a wide range of toxic wastes. The Dutch are planning a central treatment facility and promoting, through research and public education, the use of manufacturing technologies that produce less waste. And Norway, with fewer wastes than the industrial giants such as West Germany, is developing a decentralized set of technologies and management strategies. The Norwegians rely whenever possible on existing industrial facilities to destroy their toxic wates, and have led the world in the effort to retrofit cement kilns for high-temperature incineration of organic wastes.

In light of these efforts, America's continued enthusiasm for land disposal seems not only misguided but downright mystifying. Moreover, when one observes how relatively simple, inexpensive, and elegant are some of the techniques employed by our European competitors, Washington's emphasis on securing toxic landfills for future dumping appears profoundly inconsistent with our longstanding leadership in technology.

Communal Waste Destruction

Denmark has joined the technical leaders through its Kommunekemi, or "community chemical" plant. Located near the town of Nyborg on the island of Funen, the facility stands at the geographical center of Denmark and functions as the centerpiece of its toxic-waste control system. Although Kommunekemi is a government-owned waste-management firm, it makes sizable profits from consulting with other countries. It also serves as a model for other nations in search of hazardous-waste solutions.

The core of the Danish system is a network of chemical-waste collection and transfer stations, situated throughout the Maryland-sized nation to lower transport costs as well as risks. The 21 industrial-waste transfer stations, located 20 miles or less from each of Denmark's major industrial firms, are owned and operated by the muncipalities in which they are located. Some of the stations operate a pickup service for industries in their area, sending out flatbed trucks to collect drums of wastes or tank trucks equipped with vacuum pumps to collect liquids and sludges.

Linked to these transfer stations is a network of more than 275 drop-off stations for poisonous household chemicals. For example, old medicines

PHOTOS: GARY A. DAVIS

The Danish government offers firms as much as a 15 percent subsidy on processes that reduce pollution at the source.

can be dropped off at pharmacies, dead mercury batteries can be delivered to places where new batteries are sold, and other household toxins such as paint thinners and pesticides may be delivered to certain paint shops. There they are sealed in government-approved containers and shipped to the nearest transfer station for transport to Kommunekemi. By bringing their household poisons to these stations, the citizens of Denmark perform a public service while reminding themselves of the toxic wastes that directly result from the products they purchase, use, and throw away.

The entire system feeds about 60,000 tons of used oil and chemical waste to the Kommunekemi plant each year for detoxification and destruction. Three rotary kiln incinerators at Kommunekemi destroy 50,000 tons of organic solvents, sludges, and oil wastes produced each year by Denmark's petrochemical, pharmaceutical, paint, and plastics industries. The remaining 10,000 tons of inorganic wastes are treated separately.

The rotary kiln incinerator is the workhorse of most European treatment plants, destroying organic wastes at temperatures in excess of 1,200° C with an efficiency of 99.9999 percent. These incinerators have four elements. The kiln, a long rotating metal cylinder over 10 feet in diameter, burns solids, sludges, and liquid waste directly or in their original contaminated drums. An afterburner insures complete combustion of gases from the wastes. A waste-heat boiler recovers heat from the hot exhaust gases. And an air-pollution control system cleans the exhaust gases. The incinerators at Kommunekemi generate about 30 tons of steam per hour. Fed into the district heating system of Nyborg, this steam provides 60 to 65 percent of the heating demand for the town of 12,000 people.

A series of chemical and physical processes at Kommunekemi detoxifies liquid inorganic wastes from the metal and electronics industries. These wastes are generally very acidic or basic and usually contain highly toxic cyanides and heavy metals, such as chromium, cadmium, and nickel. The treatment procedures, performed in tanks, destroy cyanides by oxidizing them with sodium hypochlorite, a common swimming-pool chemical. Other processes neutralize acids and bases, chemically reduce hexavalent chromium to a less toxic form, and precipitate heavy metals as insoluble solids, which are filtered out of the remaining liquid. This liquid is discharged to the city sewer system if its content of heavy metals does not exceed strict limits.

All that remain for disposal from both the incineration and inorganic treatment units are solid residues constituting less than 25 percent of the original waste volume. Because these residues are relatively nontoxic and are in a more immobile form, the risks they pose to the environment and public health have been greatly reduced. They are deposited in a special, solids only, landfill on the island about 15 miles from the plant.

Kommunekemi was built after passage of Denmark's chemical waste law in 1973. This pivotal act placed the responsibility for proper waste management at the city and county levels, thus maximizing a sense of local responsibility for the proper treatment of wastes. Denmark's municipalities formed a consortium to finance construction of the Kommunekemi plant in 1975 by awarding it an interest-free loan, with repayment not starting until 1985.

The waste law requires companies to deliver all chemical wastes to the municipal transfer and collection stations unless they receive special permission to manage them on-site. After the wastes are delivered to Nyborg, all decisions on the proper management are made by the chemical engineers of Kommunekemi, subject to oversight by the National Environmental Protection Agency. This system forces all businesses to point their hazardous-waste decisions in the direction of destruction at the Nyborg facility.

Kommunekemi charges most companies for treating their wastes so it can recover all operating costs and repay capital costs. Charges range from about $30 per ton for processing some inorganic liquids to over $400 per ton for processing hard-to-burn chlorinated organic compounds such as PCBs, which cannot be safely burned in incinerators working at lower temperatures. However, Kommunekemi actually pays some generators for organic wastes with a high heating value, such as conventional waste oils. The interest-free, deferred-payment loan given Kommunekemi by the municipalities represents a significant initial subsidy for waste management. Concerned that the subsidies might discourage companies from decreasing the amount of waste they generate, the Danish government now offers firms as much as a 15 percent subsidy of the capital costs of in-plant modifications and new processes that reduce pollution at the source.

Hazard definition	Commonly used indicators
Ignitability	
Direct: exposure to heat, smoke, fumes	Flash point, fire point, autoignition temperature
Indirect: dispersion of hazardous byproducts	
Corrosivity	
Direct: destruction of living (tissue) and non-living surfaces	pH level; acid or base
Indirect: influence on solubility and transport of hazardous compounds	
Reactivity	
Direct: evolution of heat, pressure, gases, vapors, fumes	Violent reaction with water
Indirect: several aspects of chemical reactions when compound solutions are mixed or initially interact	
Toxicity	
Produces adverse effect (death or irreversible changes in living organisms)	Range of acute and chronic test results

Hazardous wastes cause a variety of ill effects beyond simple poisoning. Hence, any technological and managerial measures that reduce the amount of waste in landfills will improve health and safety. (Data: Daniels, 1981)

Big Government Meets Big Business

Roughly the size of Ohio, the West German state of Bavaria generates the usual range of recalcitrant toxic wastes. About 150 thousand tons are taken each year to seven collection stations throughout Bavaria. There, wastes are significantly reduced in volume by a series of simple steps that include separating oil from water, neutralizing acids and bases, and thickening sludges for ease of transport. Then the wastes pass on to one of Bavaria's three major destruction facilities, such as the Ebenhausen incineration and treatment facility owned by the Gesellschaft zur Beseitigung von Sondermüll in Bayern. The twin stacks of the GSB (literally, "the company for management of special wastes in Bavaria") rise from thick barley fields not 30 miles from Munich.

There wastes confront either GSB's two rotary kilns or its inorganic treatment plant, both similar in design and efficiency to the Danish facility. GSB also recycles about 2,000 tons of waste solvents from the electronics and automobile industries each year at a plant near Munich. After distilling out the impurities in solvents, GSB can then resell them. Solid residues from the GSB incinerator and inorganic plants end up in the Gallenbach landfill about 30 miles from the Ebenhausen plant. In dread of future Love Canals, the Bavarians generally prohibit the dumping of hazardous liquids and untreated toxic wastes in any landfill within their state.

Distrusting private waste-management firms, Bavaria created GSB in 1970 as a partnership between state government and the industries that generate hazardous wastes. GSB is a statewide, nonprofit toxic-waste-management corporation. The chairman of the board is the Bavarian minister of environment; four other board members come from state government, three from industry, and three from local governments. Because of this balanced ownership and power, the GSB may prove more capable of making long-term investment and cost-benefit decisions than conventional corporations.

Yet government and industry do not always share ownership of waste-treatment facilities in Bavaria. One heavily industrialized district in the state, concerned about water pollution from hazardous-waste dumping, formed its own waste-management firm, the Zweckverband Sondermüllplätze Mittelfranken, (the "public special waste facility in Mittelfranken") or ZVSMM, in 1966. Serving 4,000 industrial firms, ZVSMM is wholly owned by the towns and counties of this district of 3.7 million people. The firm operates the Schwabach incineration and treatment facility, constructed in stages from 1968 to 1972, exclusively for chemical wastes generated within the district.

Whether jointly owned like GSB or owned and operated exclusively by government like ZVSMM, all treatment facilities in Bavaria are heavily subsidized by state funds. The state has contributed about $11 million to GSB out of a total investment of about $45 million. Waste-treatment charges ranging from $30 to $400 per ton enable GSB to recover both its operating costs and additional capital expenses. Until recently, the capital investments of ZVSMM were funded entirely by the towns and counties in Mittelfranken. However, the state of Bavaria will contribute 40 percent of the cost of a new incinerator for the Schwabach plant this year, on the theory that quality waste control requires significant investment from government.

Since high-tech waste treatment will always have difficulty competing with lower-cost inexpert handling, Bavaria regulates hazardous wastes stringently. The State Waste Plan requires that all chemical wastes be turned over to GSB or ZVSMM, unless firms obtain special permission to treat wastes on-site or to export them to another state or country. The Bavarian environmental agency oversees the en-

The lesson from Europe is that treatment facilities can virtually eliminate the need for land disposal of wastes.

tire operation at both GSB and ZVSMM, and it determines exactly what wastes can or cannot be disposed of in landfills.

Another German state, Hesse, also decided that government should be heavily involved in managing chemical wastes. HIM (the Hessischen Industriemüll, or "Hessian industrial waste") was formed in 1974, years before hazardous waste became an international concern. A nonprofit corporation owned 75 percent by 25 Hessian companies and 25 percent by the Hessian government, HIM is governed by a board with three government and eight industry votes. HIM has a monopoly on off-site management of chemical waste in Hesse, since it owns the Biebesheim incineration facility and two recycling and physical/chemical treatment plants near Frankfurt and Kassel. It also plans to construct a secure landfill in Mainflingen for treatment residues. These HIM facilities are closely monitored by the state environmental protection agency.

HIM's incinerator is West Germany's newest and most efficient waste-destruction facility. Opened in 1981, the plant is sandwiched between two refineries near the town of Biebesheim, not far from the Rhine River. Two rotary kiln incinerators burn up to 50,000 tons of organic wastes each year—including PCBs—in solid, liquid, and semisolid form. The incinerators are equipped with a novel scrubbing system that cleans the exhaust gases with liquid that is rapidly evaporated to leave only a dry, easily managed powder for disposal. Residues from this intense burning go to landfills outside Hesse or to underground salt mines at Herfa Neurode in Hesse, where they are stored far below the water table.

Although private industry constructed the original HIM facilities, the Hessian government now pays most of the cost of the new ones such as the Biebesheim incineration plant. The government will recover its investment through fees for waste treatment, raising charges over an extended period of time so that they are not burdensome. Nonetheless, current incineration prices are high—well over $500 per ton for certain highly hazardous chlorinated organics. The government suspects that these prices are tempting some Hessian companies to transport their wastes to other states or countries. Yet as the rest of West Germany upgrades its rules, such loopholes will close.

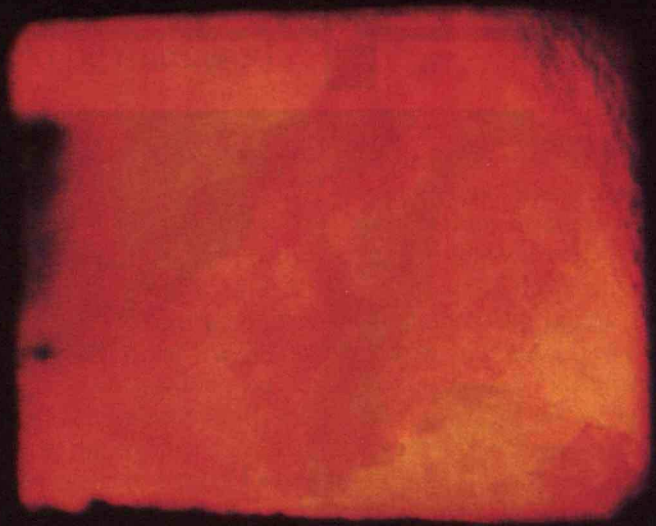
The high prices are also encouraging industries to look for ways to reduce their volume of chemical waste. In fact, the Hessian government has begun enforcing a policy that requires all new industrial facilities and any major modifications in old ones to include the best available technologies for reducing pollution and recycling wastes internally. Industry has challenged this policy, probably the first of its kind in the world, in court, but it may very well stand as a strong mandate for preventing pollution at the source.

Following the Leaders

Other European nations have awakened to the dangers of land disposal in the past decade. Sweden created a national waste-management firm, called SAKAB, in 1976, owned by the national government (96 percent), the Swedish Municipal Federation (2 percent), and the Waste Treatment Foundation (2 percent). SAKAB planned a central incineration and treatment plant and a network of collection and transfer stations to be completed this year. Muncipalities will collect and transport the wastes, which must be treated by SAKAB unless a generator receives permission to treat waste on-site. Sweden has also been a leader in reducing the amount of priority wastes by restricting the use and sale of such products as mercury, PCBs, and cadmium.

Finland founded a waste-management firm in 1979, owned equally by the national government, the municipalities, and Finnish industries. The firm will detoxify approximately 70,000 tons of hazardous wastes each year at a centralized incinceration and treatment facility in southern Finland. The contract to design the system was awarded to the Danish firm Chemcontrol, of which Kommunekemi is a partner, and the plant is due to start up in 1986.

In the Netherlands, which banned land disposal of hazardous wastes in 1979, a lack of centralized treatment facilities has forced Dutch industries to treat wastes on-site, ship them out of the country, or dispose of them illegally (athough a few legal exemptions have been granted). The Dutch have recently proposed a central treatment facility to manage some 200,000 tons of hazardous wastes per year, now mostly shipped out of the country. The Dutch are most innovative, however, in their emphasis on waste reduction and recycling. For example, the chemical industry runs a successful waste exchange—a clearinghouse for information on wastes that can be used as raw materials in other manu-



Departing in a blaze of glory, a drum of hazardous wastes burns inside the Biebesheim waste facility (inset, above) of the West German state of Hesse. The process reduces waste to nontoxic ash (inset, right) that occupies one-tenth of the original volume.

facturing processes. And Dutch law allows the government to prohibit manufacturing processes whose wastes are very difficult or impossible to manage safely.

Lessons From Europe

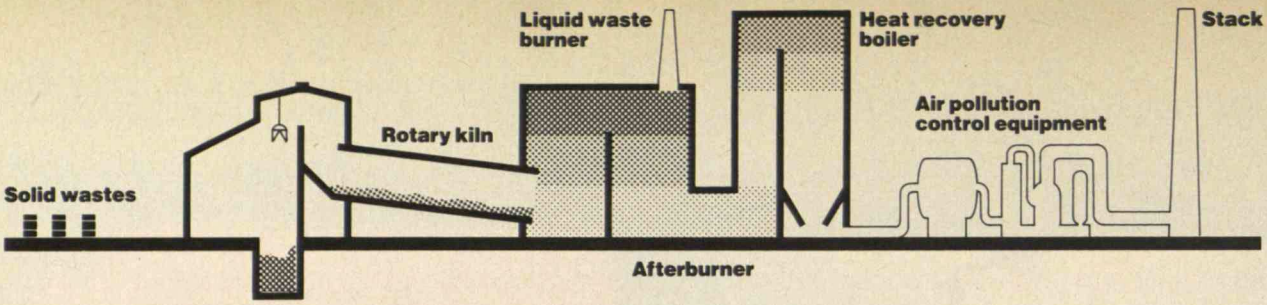
The point of these examples is not that management of hazardous waste in Europe is perfect. European nations are not without their Love Canals and similar problems. The strict Dutch laws stemmed from the discovery of over 1,000 old chemical dumpsites that may be dangerous to human health. In 1980, 268 families had to move from a housing development built above the Lekkerkerk dump—a former marsh filled with rock, gravel, and drums of chemical wastes—while cleanup crews began the long, expensive task of decontaminatng the area.

Some hazardous wastes still fall through the cracks, owing largely to inconsistencies in the regulation of hazardous wastes among European nations. Countries where standards are lax have become havens for wastes from countries with strict requirements, posing problems for governments investing in expensive treatment facilities. Great Britain and Belgium still allow hazardous wastes to be dumped in the ground, for example, while East Germany has created a huge dump near the West German border that accepts any waste from any country, at cut-rate prices designed to lure hard Western currency.

The obvious but often overlooked lesson from Europe is that detoxification facilities exist that virtually eliminate the need for land disposal of untreated chemical wastes. Safe management of hazardous waste in this country need not await the advent of new, "space-age" methods. We have the technology; what we lack is sustained political will.

European governments have shown that will by fully committing their resources and authority to recycling, treatment, and incineration facilities. The question that we should be asking in the United States, where the dump is still king, is "How do we move beyond dumping?" The European success has raised some critical issues for American managers and policymakers.

☐ *Is government ownership of hazardous-waste treatment facilities necessary and appropriate?* Of-



The rotary kiln incinerator (top) is the workhorse of most modern European plants that treat toxic organic wastes. The device typically operates at temperatures above 1,200°C with an efficiency of 99.9999 percent.

Inorganic wastes are treated by a mix of chemical and physical processes. Photo shows the dry, compacted residue produced at the Danish Kommunekemi plant. (Data: California Governor's Office of Appropriate Technology)

ficials in European countries with government-owned facilities tend to distrust private-sector management, insisting that coordinating treatment of hazardous wastes is a necessary, though burdensome, public function. For them, control of hazardous waste, and pollution in general, carries risks too great to leave entirely to seekers of short-term profits. Dr. Ranier Mixlsperger, director of Bavaria's pace-setting hazardous-waste regulatory program, explains: "Because of the inherent dangers of hazardous wastes, we decided that private waste management would create too great a risk to the public and the environment. If the government both owns the hazardous-waste facility and regulates its operating excellence, we have stronger leverage to upgrade the control of these significant risks."

Government does intervene in managing some waste in the United States, such as municipal garbage, but those practices are certainly not the norm. Sustained and blatant government intervention is more common in Europe—and more easily tolerated by industry, large and small. This control may be especially tolerated in the area of hazardous-waste management because governments have also assumed some of the expense and liability. Furthermore, because government organizations manage toxic wastes in Europe, industry must decipher and comply with less of a maze of complex regulations. As a result, Denmark and West Germany have avoided America's two most paralyzing regulatory battles—deciding what qualifies as a regulated toxic waste, and how these wastes should be managed to ensure public safety and environmental quality.

☐ *Who will pay for hazardous-waste treatment facilities?* European nations have heavily subsidized the construction and operation of treatment facilities to keep costs to industry at a reasonable level. When only short-run costs are taken into account, the costs of treatment technologies are generally much higher than the price of conventional land disposal. Governments in this country can aid the shift to treatment facilities by financing their construction or providing low-interest loans or tax breaks to private waste-management firms. We must be careful, however, not to subsidize waste disposal so much that we discourage nascent efforts to reduce the generation of wastes at the source.

☐ *How can we site treatment facilities in the United States?* Most of the European facilities operating today were sited *before* risk became catastrophe—that is, before land disposal of hazardous wastes created the crisis that today is recognized the world over. As a result, public acceptance has been quicker, more efficient, and less costly to European businesses. This may be the ultimate lesson from Europe: preemptive activity, in the long run, gains greater respect from the community learning to accept the nature and necessities of high-risk management. Public trust in government has become the essential requirement in siting controversial facilities. The profound question facing Americans over the next two decades is whether policymakers can gain the public trust by enacting strict controls on disposal of hazardous wastes. Only then will the public agree to siting safe and reliable destruction facilities in their locales.

This latter question is especially pressing, because even the latest high-tech European treatment facilities have not been immune to public opposition. The Biebesheim incinerator, opened in 1981, encountered considerable opposition from local residents. They agreed that destruction of hazardous waste is necessary but did not want the facility in their com-

DIAGRAM: OMNIGRAPHICS

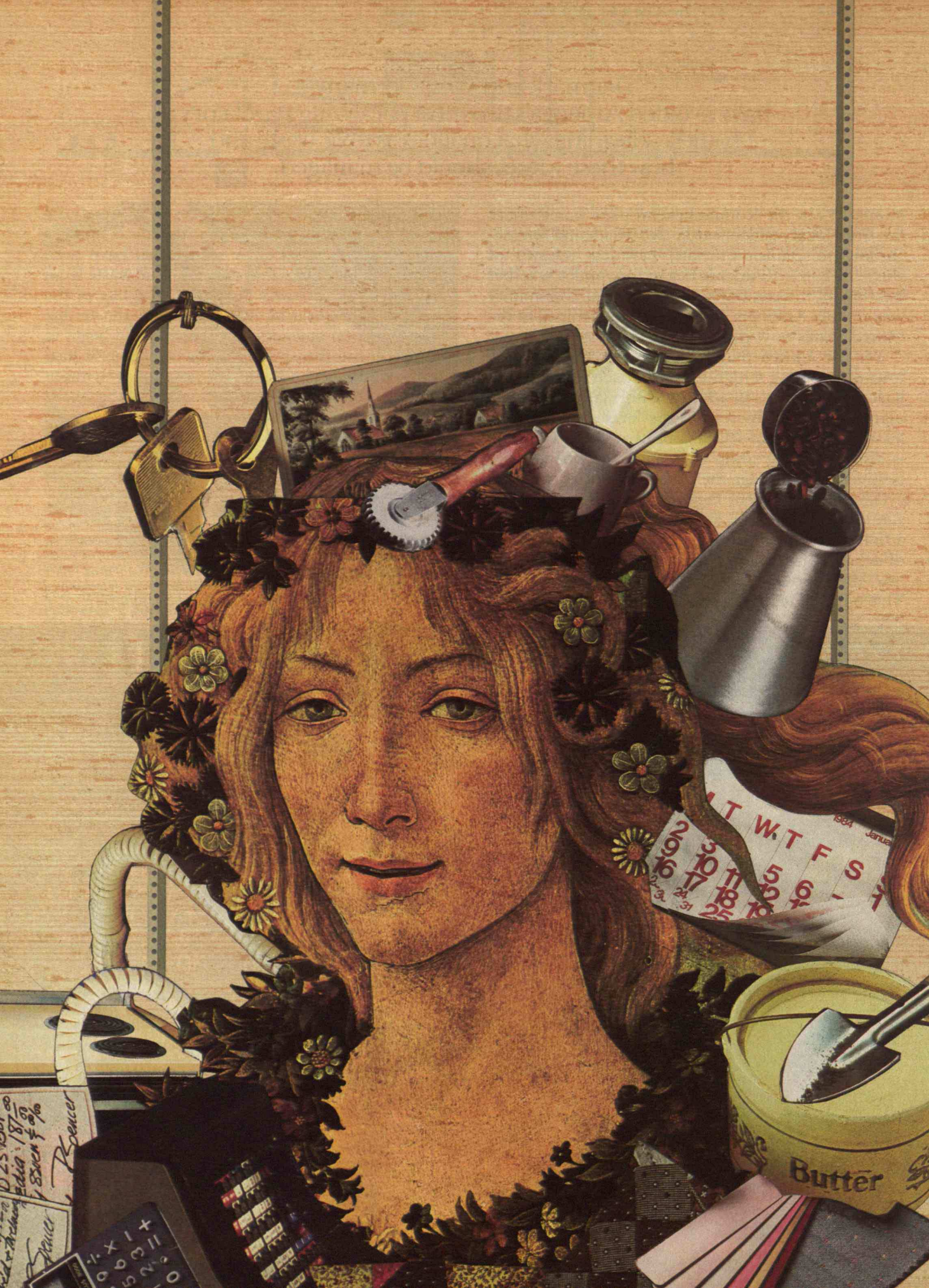
Denmark and West Germany have avoided America's two most paralyzing regulatory battles—deciding what qualifies as toxic waste and how these wastes should be managed.

munity. Even the Kommunekemi plant came under fire from local residents after two accidental but (according to Danish officials) harmless releases of waste in 1982. Residents began to wonder whether treating all the country's wastes in their community was unfair. Attempts to build waste facilities in the United States now provoke similar hostility.

Yet the United States has taken tentative steps toward adopting a high-tech approach to managing hazardous wastes. In 1983, California began a regulatory program to restrict the land disposal of at least 40 percent of its hazardous wastes. The state is also providing siting assistance and financial incentives to encourage the construction of private recycling and treatment facilities. New York imposed similar restrictions on land disposal in the spring of 1984. And this spring the U.S. Senate began a series of debates on amending the critical hazardous-waste law, the Resource Conservation and Recovery Act. This bill, originally passed in 1976, was designed to encourage the recovery of resources from America's toxic waste, and to lessen the burden on landfills.

But since 1976, RECRA regulations have been riddled with loopholes that exempt more waste from control than is currently regulated. The fate of the American detoxification industry awaits the verdict on these pivotal amendments, which could begin to shift the entire thrust of U.S. management of hazardous waste beyond land disposal. For without comprehensive means of ensuring operating excellence, the technological methods for managing waste are no more useful than half a pair of scissors.

BRUCE PIASECKI, professor of environmental history at Clarkson University's Center for Liberal Studies, is coordinating editor of Beyond Dumping: New Strategies for Controlling Toxic Contamination *(Greenwood Press, 1984) and president of the American Hazard Control Group. GARY A. DAVIS, a chemical engineer and environmental attorney practicing in Knoxville, Tenn., is a principal author of* Alternatives to the Land Disposal of Hazardous Wastes *(California Office of Appropriate Technology, 1981) and a researcher for the International Institute of Applied Systems Analysis in Laxenburg, Austria.*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Changes in domestic technology have not always liberated women. Nevertheless, the role of the homemaker as manager-worker can provide a model for improving industrial productivity.

The Other Industrial Revolution: Lessons for Business from the Home

BY ROSALIND WILLIAMS

THE triumphant march of technological progress has long been identified with railroads, mills, steam engines, space ships, and other heroic devices. However, some historians have recently turned their attention to the "other" industrial revolution in the home, rescuing from oblivion the humbler technologies of upkeep and restoration such as stoves, water closets, light bulbs, and washtubs. These devices might not propel humanity down the ringing grooves of change, but they keep it moving along the ruts of daily life. They are essential because humanity must endure before it can progress.

But the study of household technology is doing more than reclaiming the neglected past of everyday material life. It also suggests an agenda for the future, as the organization of housework can be a managerial model for industry. Compared to standard industrial models—the factory assembly line and the corporate flow chart—households may seem relics of the preindustrial, even feudal, past. But today there is a vague but widespread belief that American

ILLUSTRATION: CAROL WALD

An 1897 magazine advertisement for Pearline

industry needs to adopt more flexible modes of organization to become innovative and competitive again. Households can serve as pilot plants in this effort because the industrial revolution in the home has evolved very differently from that in the factory. Domestic management tends to be a synthesis of labor and ownership rather than a hierarchy. Domestic technologies tend to be flexible and organized around appliances rather than assembly lines.

Anyone can who has struggled to manage a modern home can testify that domestic technologies are by no means ideal. Still, because they exhibit a concern for upkeep and nurture, households can offer guidance to a society confronting the twin challenges of improving industrial productivity and preserving the environment. Labor in the home still accounts for about half the total work time in the United States, but this immense reservoir of experience has scarcely been tapped. The lessons of the other industrial revolution should be brought to bear upon the effort to reindustrialize outside the home.

Industrialization has relieved men of far more of their traditional chores than women.

From Homespun to Factory Made

At a Connecticut county fair in 1851, Congregational minister Horace Bushnell delivered a speech proclaiming the end of "the age of homespun" in which each homestead wove and spun its own cloth. The coming era, Bushnell predicted, would be "the day of roads." Fewer goods would be made in the home and more would be purchased, shipped from factories along the various roads of modern technology: railroads, steamships, canals, and newspapers as well as highways. Families would be less ruggedly independent, but they would also enjoy a less arduous life, as water and steam power replaced "mother and daughter power."

At the time Bushnell spoke, the frontier dividing preindustrial from industrial households was ragged. Its position varied according to social class, as wealthier homes were modernized before poorer ones, and geography, as the city was industrialized before the country. Still, the fact that housekeeping was being transformed radically and rapidly was clear to all.

Home spinning and weaving were disappearing, except in the backwoods. Another household staple, flour, was also ceasing to be "homespun," or homegrown. In the late 1700s merchants in Eastern cities had begun to manufacture flour in mills driven by water power, where conveyer belts moved the grain, automatic hoppers sorted the various grades, and improved stones ground more fine, white flour per bushel of wheat. At first, most of this flour was exported, but it soon replaced the coarser types made in local grist mills. The decisive shift to merchant flour came between the 1820s and the 1840s, when new waterways such as the Erie Canal greatly reduced the cost of transporting this bulky commodity.

One effect of industrialization, then, was to remove tools such as scythes and spinning wheels from the home, shifting the family's focus from production to consumption. However, at the same time, new tools, or significantly improved versions of old ones, were being added. The most dramatic example was the glowing, coal-fired cast-iron stove that replaced the flickering, wood-fired open hearth. German and Scandinavian immigrants had long used

simple box stoves for heating. Early nineteenth-century tinkerers added a box with a door to serve as an oven and a circular hole on top to hold a pot. By the 1870s, the cookstove was a major appliance with up to eight cooking holes, two or three ovens, attached reservoirs for hot water, movable grates, ash sifters, and dampers. The transition from hearth to stove encouraged the move from wood to coal as the primary domestic fuel, for coal burned longer than wood, required less hauling, and burned somewhat more cleanly. This step toward energy efficiency was also a step away from energy independence, as wood had generally been a "homespun" fuel, while coal was a purchased product carried over a "road," usually a railroad.

Plainly, then, merchant flour and cast-iron stoves are as much emblems of the early industrial age as steam engines, cotton mills, and railroads. However, the second stage of industrialization—the late-nineteenth-century move to electricity, steel, and petroleum—transformed daily life even more decisively.

In the kitchen, a deluge of cans and boxes of prepared foods followed the bags of merchant flour. Breakfast cereals were made in automated mills beginning in 1880, and the first automated commercial canning factory in the United States opened soon after. By the turn of the century, brands such as Campbell's soups, Quaker Oats, and Heinz "57" were being marketed nationally, and the can opener had become a standard piece of kitchen equipment. Meat was frozen for shipment beginning in the 1880s, and quick-freezing techniques that enabled fish, fruits, and vegetables to be defrosted without becoming tasteless mush were devised in the 1930s.

Ad appearing in July 1908 Ladies' Home Journal

Although household technologies have changed drastically over the past half-century, the time homemakers spend on housework has remained the same.

A half-century after the age of homespun ended, so did the age of homesewn. Ready-made men's clothing was marketed first (as late as 1894 the Sear's catalog didn't carry any women's wear), but by 1920 most women and children had also switched to factory-sewn garments.

As houses filled up with new products, an even more striking transformation occurred: the houses themselves were threaded with pipes, ducts, vents, conduits, and wires furnishing a continuous supply of water and energy. These utilities, the "roads" of the second stage of industrialization, probably changed household routine more than any other technologies.

Sizable U.S. cities began to construct water-supply systems before the Civil War, and afterward they built sewer lines to dispose of storm and waste water. At first, well-to-do homeowners paid fees to connect their houses to the public systems, but by the turn of the century most city residents had access to running water, even though tenement dwellers often had to share a cold-water tap and toilet.

Construction of the gas-supply network began in the early 1880s, again because of government initiative. Municipal gas systems were installed to light streets as well as some workplaces and a few private homes. However, when kerosene and later electricity companies began to compete to supply domestic

lighting, gas companies started to promote their fuel for heating, hot water, and cooking. By 1930 gas was the most popular cooking fuel in the United States, used by twice as many households as coal and wood combined.

Coal persisted as a source of room heat because it could be used in existing fireplaces and free-standing stoves. Only the well-off could afford to buy a furnace and retrofit an entire house with pipes and radiators. Not until the 1920s and 1930s did many homeowners of more modest means install central heating, and only in the 1930s and 1940s did the price of heating oil fall enough to make it a serious competitor to coal.

The transition from coal to petroleum products was one cornerstone of the domestic energy revolution. The other was electrification. In 1907 only 8 percent of American homes were wired for electricity; by 1941 80 percent were. Electricity was first used for lighting, but the development of a reliable, compact electric motor quickly led to widespread use of appliances such as vacuum cleaners and electric sewing machines. By the beginning of World War II, half the families in the United States owned electric washing machines and refrigerators, and electric ranges were competing with gas ones.

A century after Pastor Bushnell heralded the dawn of a new era, the little house on the prairie had been transformed into the little house in the suburbs. New products, appliances, and energy sources had meshed to bring about this other industrial revolution—a process that continues today. The modern bathroom is supplied not only with hot and cold running water but also with a cabinet full of cosmetics and health and cleaning products. Into the kitchen flows not only water, electricity, and perhaps gas but also a weekly influx of packaged mixes and ready-made foods that go into blenders and toaster-ovens. The laundry, the third "high-tech" area of the household, contains not only an automatic washer and drier but also a small laboratory of soap powders, bleaches, and softeners compatible with modern "miracle" fabrics. Considered as a machine for living, the modern middle-class American house is a complex and highly evolved tool.

A decade ago, Ruth Schwartz Cowan, a history professor at the University of New York at Stony Brook, decided to try to show how these technological changes have increased productivity in the home and released women to enter the paid labor force.

However, she soon discovered that her hypothesis was mistaken. She found that although household technologies have changed drastically during the past half-century, the time women not employed outside the home spend on housework has remained nearly constant—between 53 and 81 hours a week, depending on the type of household and on the definition of "housework."

Promises of Liberation

This troublesome fact contradicts the assumption, nearly universal in the nineteenth century and still widespread today, that technological progress saves labor and frees people for "higher" pursuits. Homemakers are not alone in facing this paradox. The 70-hour-a-week executive, the moonlighting schoolteacher, and the overtime-weary blue-collar worker have just as much reason to ask what went wrong.

Industrialization has brought unforeseen social results because it has changed not only how work is done, but also who does it and what is done. In the case of housework, Cowan found that industrialization has done much more to relieve men of their traditional chores than women. When the coal-burning stove replaced the wood-burning fireplace, men no longer had to cut, carry, and split wood, but women still had the time-consuming tasks of stoking and polishing the stove, adjusting the dampers, and sifting the ashes. The shift to merchant flour meant that men no longer had to grind grain, but women spent the same time cooking it. Likewise, the male domestic occupations of leatherworking, butchering, and furniture making all disappeared during the nineteenth century. Factories produced boots, shoes, canned and refrigerated meats, and furniture, but

Left: Researchers time a woman using an eggbeater at the Applecroft Home Experiment Station on Long Island. Christine Frederick founded the center in 1910 to study ways to improve the efficiency of home technologies. Far left: Woman demonstrates the advantage of using a long-handled broom instead of a short-handled one.

did not eliminate mending, polishing, and cooking.

At the same time the homemaker was losing hired help. Live-in servants were never the rule: in 1870 there was one servant for every 8.4 households, and a uniformed maid was a luxury restricted to the upper middle class during the century or so when immigration furnished a supply of cheap female labor. But more informal and temporary hired help had long been available, including indentured servants in colonial times, "hired girls" and "hired hands" who lived with a family before setting up their own households, and laundresses and seamstresses who appeared intermittently. Many homemakers could also count on unpaid aid from maiden aunts, unmarried daughters, and grandmothers.

But these helpers were eventually siphoned off by more attractive entry-level jobs in business and industry. The expanding job market also drew away "the man of the house," who was under more pressure to earn a cash income to pay for purchased goods. At the same time, "the lady of the house" had fewer opportunities to earn money in cottage industries. The classic example is the textile business, where factory production put an end to home production for cash as well as subsistence. This trend was also evident in other industries. Between 1910 and 1920 alone the number of dressmakers and seamstresses working outside factories dropped by 47 percent, independent laundresses by 25 percent, and women running boarding houses by 19 percent.

Industrialization, therefore, had contradictory effects on the American household. Although the private home became technologically woven into networks of marketing and utilities, it became socially far more isolated. Americans began to refer to home and work as "separate spheres," implying that the world of the family was a different universe from the workaday world. Furthermore, people began to assume that this separation was a product of nature, not of industrialization. Women reigned in the domestic sphere while men ruled in the industrial one. Like Robinson Crusoe, the homemaker could look at her domain and proclaim, "I am a monarch of all I survey"; but she was queen of a deserted island with no Man—or Woman—Friday for help and company.

From Lento to Presto

Housework has also continued to be time consuming because standards have changed radically. Eighteenth-century housekeeping norms are as much relics of a bygone age as spinning wheels and butter churns. Our ancestors' diet of one-pot stews and soups, salted meats and fish, and coarse breads would today seem intolerably monotonous and unhealthy. Home spun clothing would seem revoltingly dirty, as outerwear made of heavy woolens, felt, and leather was virtually unwashable, and linen underclothes were rarely laundered. Houses heated with wood or coal and lighted with candles, kerosene, or gas accumulated strata of grime that even bold Victorian color schemes could not disguise.

The basic domestic tasks—cooking, laundering, and cleaning—can now be done much faster, but each is also repeated much more frequently. The rhythm of housework has accelerated from lento to presto. Instead of eating the same basic stew for days on end, middle-class Americans expect different foods at each meal and sigh when confronted with leftovers. When people began wearing factory-made cottons that were relatively easy to wash, laundry day became a weekly ritual (typically on Monday, as people changed clothes on Sunday and wanted to wash them before the dirt "set"). Because many families now have both an automatic washer and drier, they change clothes constantly, and almost every day is wash day. In the nineteenth century, spring house cleaning became an annual event when carpets and drapes were beaten, walls and windows scrubbed, and furniture polished to remove the winter's soot. Today, many homemakers vacuum weekly.

A powerful alliance between science and advertising has encouraged these changes. In the late nineteenth century, the germ theory of disease suggested a direct relationship between household cleanliness

Electricity Now Does All the Washing and Wringing

We now attach an electric motor to the famous 1900 Washer. It operates the wringer, too. Connect it with a light fixture, as you connect a table lamp. Turn on the current as you turn on the light.

The Washer then operates just like our hand washer, only you don't need to touch it.

When the washing is done, move a small lever, and the motor connects with the wringer. The one motor, operating both the washer and wringer, does every whit of the work. Please think what that means. The hardest drudgery there is about housework done by two cents' worth of electricity.

Servants happy; laundry bills saved; clothes lasting twice as long. For the "1900" does washing better than any other method known.

Now electricity makes the washer go. Doesn't that sound like a new era for women?

Send No Money—We Pay Freight

This outfit does just as we claim. Does all of the washing, all of the wringing. Does the work better than you can do it by hand. Does it with less wear on clothes.

The facts, we know, seem too good to be true. So we propose this:

If you are responsible, we will send you the Washer, Wringer and Motor, all on 30 days' trial. We will prepay the freight.

You don't invest a penny—don't commit yourself at all. Do four washings with it. Try it on dainty things, heavy things, everything. Then, if you think you can get along without it, we will take it back.

Your 30 days' use will be free.

You have no obligation whatever. Treat us just like a dealer who shows you a washer. If you don't want it when the month is up, simply say so.

But don't go on washing in the old way without knowing what this method means to you. Women have no right to do such hard work when electricity can do it for them.

Send first for our Washer Book, to know all about it. Then, if you'll try it, just tell us to send it on.

Please cut out this coupon—now—before you forget it.

30 Days' Free Trial

The 1900 Washer Co.,
358 Henry St., Binghamton, N. Y.
Please send me the book about the Electric Washer.
Name _____
Address _____
We have also a Canadian factory.

Ad appearing in July 1908 Ladies' Home Journal

No one seems to have noticed an experiment in workplace democracy much closer to home—in the American home itself.

and good health, while nutritionists promoted the concept of a balanced diet. Scientific authorities also demanded higher standards of child care. Women's magazines and self-help books counseled mothers to feed infants every four hours with carefully prepared formulas, to weigh them every day or even after each feeding, to bathe them daily at precise temperatures, to boil and bleach diapers, and, to ensure the children's mental health, to do all this themselves rather than trust hired help.

Accordingly, the good housekeeping emblem of approval increasingly resembled the stamp of scientific authority. Advertisements promised that products would keep the bathroom sanitary and the baby healthy. Ads also maintained that products and appliances would save a housekeeper time and energy, which could then be lavished on child care or some other worthy pursuit.

Today such promises of liberation seem deceptive. Housekeeping standards supposedly dictated by science appear neurotically fussy. While new products and devices might free up time in some ways, they can also gobble up more in shopping, maintenance, and use. However, this is retrospective wisdom. To homemakers of the 1920s, for whom Blue Monday meant an exhausting day of lugging, soaking, boiling, rubbing, wringing, rinsing, hanging, starching and ironing, an automatic washing machine looked unequivocally like liberation. And because these homemakers were part of the first generation to see child mortality rates fall dramatically, keeping bathrooms scrupulously clean helped allay terrible fears.

The history of housework therefore suggests that technological change may benefit some groups more than others, and that attitudes about work may change as decisively as the tools used to do it. Industrialization has transformed not only household equipment and the house itself but the people who live inside—their activities, values, and needs. Nothing speaks more eloquently against the superficial view that technological change is simply a matter of new tools and new gadgets. Instead, in changing the way we work, we change ourselves.

The New Worker

Although modern technology has made housework much less physically demanding, women often do not seem very grateful. This thought has undoubtedly crossed the minds (if not the lips) of many a weary husband, who drags himself home from the office or factory only to be greeted by his wife's complaints about all the chores she has done.

Even some feminists have accused modern homemakers of ingratitude. Rose Moss, formerly of the Wellesley College Center for Research on Women and now a management consultant, maintains that some scholarly essays on women and technology tend to "minimize what technology has done to liberate women from the idiocy of physical drudgery, repeated pregnancy, and illiterate exhaustion. Technological innovations making housework easier have not, they say, given women more time. Instead they have led to higher standards. . . . Alas, where are the waterbuckets of yesteryear? And where are the women who in the first world used to and in the third world still, in heat and in cold, pregnant and nursing, haul water several hours a day, collect and carry fuel, cook and clean so as to save both, and, lacking rest and cleanliness, at an age when we who write may still live half our lives, are old women, ready to die? More time?—technological innovations making housework easier have given us years."

Moss assumes that people should be more satisfied when their tasks are made easier by new technologies. However, homemakers today have discarded the expectations of yesteryear along with its water-

buckets. They compare themselves not to Third World women but to men of their own society, who average 1.6 hours a day of household labor whether or not their wives work outside the home.

Like the "new woman," the "new worker" is often criticized for failing to appreciate the benefits of technological progress. However, again the root of the dissatisfaction is not technological but social. Much as industry and the home are split into separate spheres, so industry itself is divided into the spheres of management and labor, with one group enjoying much more liberation through technological progress than the other. Ever since Adam Smith, the division of labor has been regarded as the key to industrial efficiency. Production has been broken down into a series of simple operations, each performed by a different worker, and the mental work of planning the operations has been separated from the manual work of performing them.

Ad appearing in November 1908 Ladies' Home Journal

> *Industrialization brings unforeseen social results because it changes not only how work is done but also who does it and what is done.*

Homemakers have long been urged to manage their homes according to these industrial norms, especially by advocates of the domestic-science movement that arose in the early 1900s. Mary Pattison, who wrote *Principles of Domestic Engineering*, set up an experiment station to apply time and motion studies to household tasks. Lillian Gilbreth, who collaborated with her husband Frank on industrial - management studies, suggested that children follow their mother as she does her chores, unwinding a string to show where she wasted motion and retraced her steps.

These observers encouraged the homemaker to think of herself as the executive of the home. The hitch was that she was not supposed to give orders to anyone—certainly not to her husband, and not even to servants, because domestic service was regarded as an undemocratic and un-American arrangement. Catharine Beecher, the best-known nineteenth-century writer of advice to homemakers, called housework "woman's profession." To shirk it, except for reasons of health, dishonored that calling, she maintained.

Manufacturers adapted this theme, promoting their products by maintaining that they performed so efficiently and reliably that a woman was better off using them herself. For example, before World War I, advertisements often showed a maid or nurse using household products. However, by the 1920s, the ads pictured the homemaker herself at work. One urged, "Don't go to the Employment Bureau. Go to your Lighting Company or leading Electric Shop to solve your servant problem."

These arguments were directed only at women's

The theory behind appliances—that technology can be so versatile that it makes sense to do a task yourself—can be liberating.

Ad appearing in May 1947 Ladies' Home Journal

sphere; no one dreamed of applying them to workplaces outside the home. Accordingly, the homemaker became a unique kind of manager—one who also did the dirty work of changing diapers, the night shift of caring for sick children, and the common labor of scrubbing floors. If the homemaker had one foot on the executive ladder, she had the other firmly planted on the factory floor. She was a new hybrid, the manager-worker.

Synthesizing Labor and Management

Today the need to bring together the separate spheres of labor and management—for reasons of democracy, productivity, or both—has become a major theme of advocates of reindustrialization. Experiments called "quality-of-work-life programs," "participative management," and "workplace democracy," often modeled after management practices in Europe and especially Japan, have this common goal.

However, no one seems to have noticed an experiment in workplace democracy much closer to home—in the American home itself. While industrial labor has become increasingly specialized, work in the home has moved toward a synthesis of ownership and operation. While industry is split between the executive suite and the shop floor, the household distinction between "upstairs" and "downstairs" has been virtually eliminated. One challenge of reindustrialization is to incorporate this great social accomplishment while avoiding its great problem of inequity based on gender. Instead of asking what the home can learn from the factory, we should ask what the factory might learn from the home.

One lesson is that technologies, especially appliances, can play a crucial role in synthesizing management and labor. Of course, people and machines are not interchangeable parts. By making the false claim that appliances can replace human aid, industry has helped keep women at home and discouraged investment in alternatives such as commercial services, which might have done more to lighten women's load. But under different social circumstances, the theory behind appliances—that technology can be so versatile and user-friendly that it makes sense to do a task yourself—could offer genuine liberation.

For example, office automation offers a splendid

The need to maintain a reasonable standard of environmental quality can be thought of as the need for global housekeeping.

Ad appearing in February 1921 Ladies' Home Journal

opportunity to use computers as appliances. To be sure, computers have turned some offices into air-conditioned assembly lines where clerical workers hunch before video display screens eight hours a day. In other offices, however, managers now prefer to do their own word processing or computer programming rather than to exchange manuscripts and data continually with support workers. Support personnel are then freed to assume more administrative responsibilities instead of stagnating in the backwaters of the typing pool. In this way, computers can increase employee satisfaction by providing a better balance between head work and hand work.

In addition to requiring a new equilibrium between labor and management, reindustrialization also involves creating a new equilibrium among industries. This second goal is usually expressed as the need to devise investment strategies—whether public, private, or some mix—that will do the most to serve long-term social and economic goals. To state the problem more philosophically, we must decide just what is worth producing.

Here too the other industrial revolution offers guidance. Historians and sociologists of housework often wrestle with the question of just what households produce and how to value this contribution. If production is conventionally defined as the extraction of raw materials and the making of consumable goods from them, then homemakers must be classed as nonproductive workers. However, standard economic terms are sadly inadequate in describing the complex texture of home life. As Ruth Cowan says, "Households are the locales in which our society produces healthy people, and housewives are the workers who are responsible for almost all of the stages in the production process."

This statement is not as sentimental as it may sound. Producing and maintaining a family are not only labors of love but also critical props of the economic order. Homes are where children are born and reared—children who need physical and mental nurture so they can someday become useful workers. Homes are also where those who work outside return to be refreshed and restored so they will be ready for another work day. A "regular" nine-to-five job implicitly assumes the existence of a shadow job: that of running a domestic support system.

When unpaid homemakers hold the shadow job,

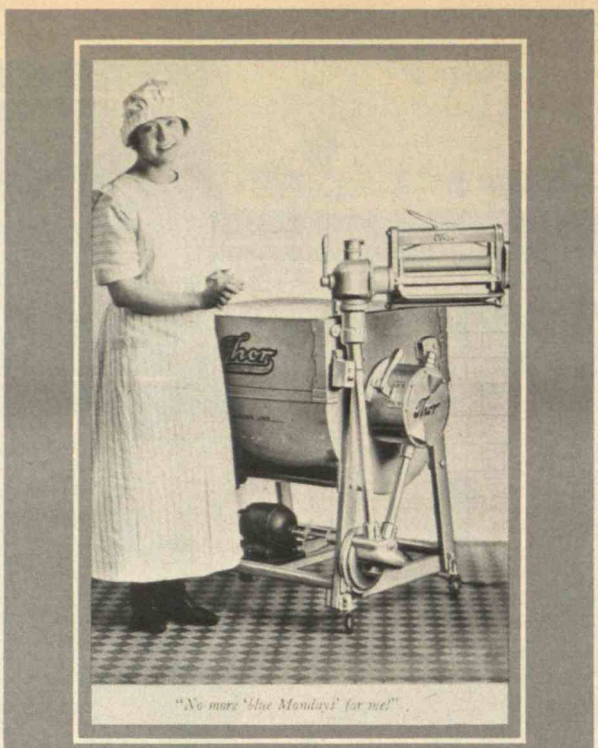

Illustration from a 1922 booklet by Christine Frederick entitled "You and Your Laundry."

society enjoys the benefits of the domestic support system at little cost. However, the era of the free lunchmaker is rapidly drawing to a close. As more women work at paying jobs, they have less time and energy for the shadow one. The family crisis of this generation is comparable to the "servant crisis" of the turn of the century, only now it is the housewifely "crypto-servants" (to borrow John Kenneth Galbraith's term) who are being lured by more attractive jobs in business. As a result, the whole family is subject to strain and stress. This time, to ensure the continued production of healthy families essential to the economy, industry will have to respond more appropriately than by selling appliances. It will have to invest in social solutions—beginning with part-time and flex-time work, longer vacations, and day care—to reduce the pressures on family life.

Industry depends upon housekeeping in a broader sense as well. The need to maintain a reasonable standard of environmental quality can be thought of as the need for global housekeeping. Here too society has avoided paying for all of the costs of industrialization. As long as the scale of industry was relatively small, companies could scatter their trash. But the dirt has accumulated to the point where it can no longer be ignored, and again the necessity of maintaining an adequate support system is becoming evident. Again, too, responsibility for maintaining that system is shifting. Government is now in the position of a homemaker who scolds her kids to pick up their rooms *or else*, who sets rules and assigns chores, and who fervently hopes that someday the kids will pick up after themselves better without so much nagging.

Industry must recognize, far more than it has, its dependence on housekeeping, both familial and environmental. Society needs to invest not just in this industry or that one, but also in the support systems underlying all businesses. Many people have pointed out the need to restore the "infrastructure," a term usually defined as bridges, roads, and the like. But the human and environmental infrastructures also need investment. These systems of repair, upkeep, and nurture—ones that produce human survival—are the crucial underpinnings of technologies that have as their goal the extraction of raw materials and the making of consumable goods. Whether or not growth has limits, it surely has prerequisites.

The fact that since industrialization men have largely ceased to do housework may have had far greater consequences than we have realized. If it is true that the work we do affects our attitudes and values, then lack of responsibility for housework may have discouraged appreciation of its industrial equivalents. The importance of sharing housework goes beyond the practical problem of who carries out the garbage. It is an essential form of education in environmental and democratic consciousness. For industrial policymakers, housework should be more than a metaphor; it should be a lived reality. As we have seen, the most effective way of changing consciousness is not through exhortation but through altering the conditions of daily life.

The greatest contribution of historians of the other industrial revolution has not been to salvage a neglected past but to rescue a forgotten present. By reminding us of the connections between the two technologies—the grand and the humble, the railroad and the can opener—they have reminded us of the connections between home and industry, women and men, survival and progress.

FURTHER READING

☐ Cowan, Ruth Schwartz, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave.* New York: Basic Books, 1983.

☐ Ehrenreich, Barbara, and Deirdre English, *For Her Own Good: 150 Years of the Experts' Advice to Women.* Garden City, N.Y.: Doubleday, 1978.

ROSALIND WILLIAMS, an historian, is author of Dream Worlds: Mass Consumption in Late-Nineteenth-Century France *(University of California Press, 1982) and a lecturer in the Writing Program at M.I.T.*

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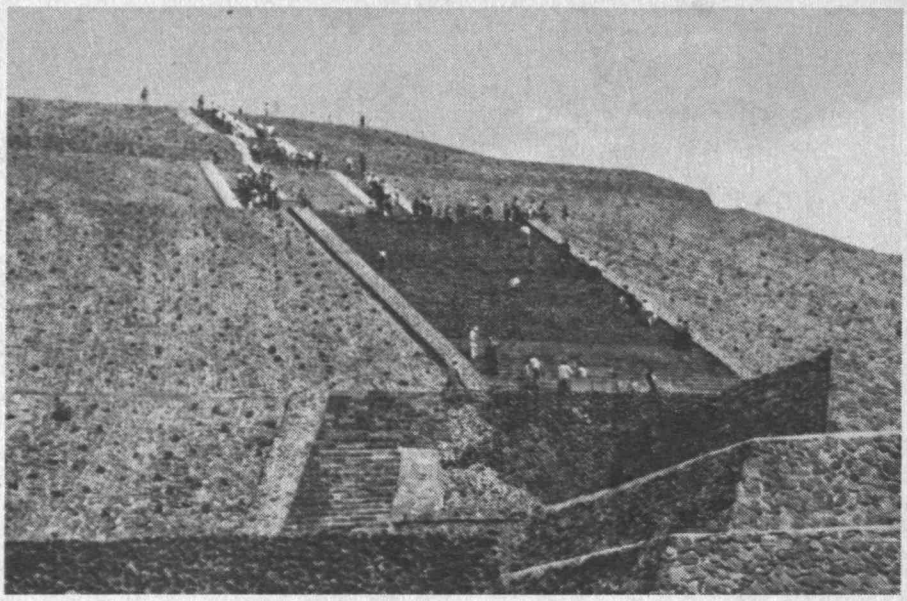
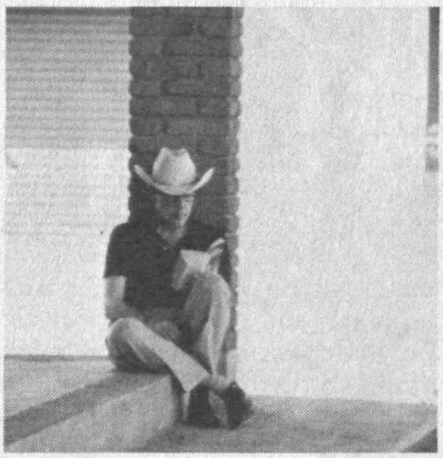


In This Issue



About the Cover

If "Tech is Hell," can Tech reunions be the insipid affairs that a lesser institution might inspire? Not likely, if our cover photo of Robert J. Holden (left), former associate dean for student affairs, and Charles H. Hart, '45, is any indication. (See the photo at the top of this page to appreciate the source of their exhaustion—those bumps on the stairs of one of the Teotihuacan Pyramids in Mexico City are people, including our heroes.)

They were among almost 100 U.S. and Mexican graduates of the Institute and friends who rose to the challenge and the delights of the 36th annual Mexican Fiesta, hosted in March by the M.I.T. Club of Mexico City.

Led by club president Rogelio Moreyra, the Mexican alumni rolled out the red carpet; Conchita Lobdell Pearson even stopped Mexico City traffic, (left, center) no small feat, to smooth out a day's touring for the group.

There were also moments of absolute peace and comfort, as provost Francis Low discovered (left, bottom). Dr. Low and his wife Natalie were the guests of honor for the week-long reunion festivities. (Photographs by Joe Martori.)

Reporting on M.I.T.

Susan M. Lewis, until recently public information officer and science writer at the University of New Brunswick, Fredericton, has joined *Technology Review* to take primary responsibility for our reporting of Institute and alumni affairs, and her name and the product of her typewriter will soon become familiar to alumni readers.

S.M. Lewis

Ms. Lewis studied journalism at Michigan State University and was an education reporter for the *Ann Arbor* (Mich.) *News* before devoting several years to parenthood. She returned to professional work at the University of New Brunswick in 1976, where she was responsible for news and feature reporting in science, engineering, forestry, and nursing.

Ms. Lewis is well embarked on the formidable task of making an acquaintance with M.I.T. and its alumni.—*J.M.*

Letters

Wanted: More Hacks

I hope Donald Davidoff's report on the Technology Hackers Association (*"How Davidoff Met the Technology Hackers Association," April, pp. A4-A7*) will stimulate many readers to recall—and perhaps document—pranks and hacks in their own experience.

The M.I.T. Museum has been gathering hack-related materials—written, photographic, and artifacts—since its founding. Recent hacks have usually been well documented, but those of previous decades are too often known only as legends. We have, for example, only the sparsest information on such infamous events as the welding of the Massachusetts Avenue streetcar to its rails, the playing of rock-and-roll over the Harvard Chapel loudspeakers, the giant icicle, the Harvard Gate closing ceremony, etc. Even events of which we have photographs are sometimes misunderstood.

Accordingly, we appeal to readers to document those pranks/hacks that they know to have occurred, or perhaps caused to happen. We earnestly seek stories (on paper or tape recorder), photographs, clippings, artifacts . . . anything at all that will document legends and lesser feats. Original materials can be returned on request, and their safety is assured while in our hands.

Warren Seamans
Director, M.I.T. Museum
265 Massachusetts Ave., Cambridge 02139
(617) 253-4444

Real Estate Computers

My partner George Vallone and I set up our own real estate development and construction company four years ago, concentrating on development in Hoboken, N.J. Despite our training, we had to learn through experience much of the knowledge and skills that M.I.T. intends to teach in its Center for Real Estate Development (*see "Real Estate Development Goes Academic," February/March, p. A16*). So we agree with M.I.T. that there are a lot of unresolved issues in our field of activity that require fundamental thinking and systematic research.

For example, we have been amazed to find how few computer programs have been prepared for construction analysis, control, and management in development operations. We'd welcome the opportunity to demonstrate programs we have developed for these purposes.

Daniel J. Gans
West Bank Construction Corp.
Hoboken, N.J.

Founding Concourse

Professor Jerome Lettvin has done many fine things and contributed to many students' educations in all sorts of ordinary and bizarre ways, but he did not found Concourse (*see "Hanging Out in Cambridge," April, pp. A2ff.*). The credit for that goes to Professors Louis Bucciarelli, Jr., Ph.D.'66, and Travis Merritt and a number of other dedicated teachers.

Steven Lubar, '76
Silver Spring, Md.

Wrong Flowers in the Garden

Your report (*February/March, page A13*) unfortunately had my message to the 1983 Sloan Fellows Convocation 180° wrong. It would better have been reported as the following:

"Preserving U.S. manufacturing by protectionist quotas would be creating a witches' garden: a few flowers for the elite of the workforce, procured at the expense of the rank and file of American labor and at the expense of lowering the nation's per capita real income. A bad bargain when understood."

Paul A. Samuelson
Professor of Economics, M.I.T.

No Sale

As some readers may be aware, early this year the M.I.T. Alumni Association received a serious offer for the purchase of *Technology Review*. The magazine would have been published under commercial auspices, with alumni receiving copies under a sales agreement.

After extensive negotiation and discussion, the association's Board of Directors voted to retain the *Review*, continuing its service to M.I.T. and the association through alumni and paid circulation. The *Review*'s Advisory Board was unanimous in recommending this decision, and the staff rejoices in the opportunity to continue and enhance the magazine's relationships with its many faithful readers.—*William J. Hecht*

ILLUSTRATION: JON MCINTOSH

M.I.T. Oar Else: Drownproof and Physically Fit on the Charles

Student View/Diana ben-Aaron

Diana ben-Aaron, '85, is majoring in humanities and materials science. Her "Student View" appears regularly in this space, and she is also serving as features editor for Volume 104 of *The Tech*.

"From their speedy oared craft did this hardy people come to rule their known world."—unknown historian.

M.I.T.'s motto is "Mens et Manus," not "Mens Sana in Corpore Sano," but that doesn't mean exercise is absent from the undergraduate agenda. To receive a bachelor's degree, one must be certified not only numerate, literate, well-rounded, proficient in a specialty, and competent in the laboratory, but drownproof and physically fit as well.

The summer before my junior year, the Department of Athletics sent me a form letter reminding me that I had done nothing to fulfill the physical education requirement. Haunted by memories of seniors I'd seen taking four gym classes while trying to write a thesis, I resolved to begin my athletic career immediately.

The swim test was the easy part—it's the only Institute requirement you can pass in 15 minutes with your eyes closed. For the gym classes, I resolved to do something really strenuous—perhaps join an intercollegiate sport. I wanted to try a sport as far away as possible from the spectre of high school gym classes, and I had some pleasant memories of a midnight canoe trip down the Charles River freshman year with some people from my living group. Somehow I ended up at the Pierce Boathouse, a coxswain on the M.I.T.'s novice women's crew.

An elderly gentleman watching the M.I.T. varsity women go under a bridge at Head of the Charles was heard to conjecture that our coxswains are chosen for their managerial ability, probably from the Sloan School. In fact, coxswains are chosen for small size. Because they do not row but steer the boat by pulling lines attached to the rudder, give the rowing commands, and encourage the rowers, it is imperative they add as little dead weight to the boat as possible.

If you aren't strong when you start rowing, crew will make you strong. If you can't manage people when you start coxing, a year of making several crucial decisions every minute in situations where a democratic decision is impossible ("Should we turn to the right or the left to avoid the B.U. heavyweights? Let's have a show of hands . . .") will teach you take charge. Certainly I was chosen to cox for my size and not for leadership ability.

I was a slow learner, taking all year to master my job. The coach switched me from coxing to rowing and back any number of times. Eventually, and probably because of my dual status, I did learn to cox. But just as with M.I.T. in general, the problem was surviving the experience in order to profit from it. I'm not sure what made me walk down Memorial Drive six times a week in the predawn or sunset vowing to quit crew and return determined to go out on the water every day for the rest of my life. I'm not sure why anyone stays with it, except that moving through the water together—and the Charles can be a lot pleasanter than you'd think—is addictive. It's difficult to explain. Crew, and especially coxing, often seems illogical.

A Brute-Force Sport

Imagine youself coxing a race. Eight of your friends are a few feet away, working as hard as they can to propel the boat forward. They look as if they're going to faint any moment. And what are you doing? Screaming at them to row harder, of course.

The wind, current, and unevenness of the rowers are always turning the boat one way or another, and you have to constantly straighten the course. If your mind wanders, you may crash the $10,000 shell—and people—into a bridge, a bank, or another boat. You must constantly be on the alert for other boats, but you can't rock the boat when you twist around to look. In the meantime, you are counting the strokes, up to fifty at a time, and cheering the rowers on at the top of your voice, probably through a megaphone or microphone. A coxswain is a timesharing system for doing all kinds of crucial things, and there's only one per boat. There is very little time to make decisions, and no way to practice your skills off the water (until someone invents an appropriate video game.) The psychological pressure is tremendous.

Imagine you are rowing a spring race, eight of you pulling yourselves, coxswain, and a 250-pound boat down the Charles. You began preparing for this in September; you have been training two hours a day all year. You rowed on the water in the fall and spring and in an indoor tank all winter. You lifted weights, ran up and down stairs and in complicated loops over the Charles River bridges, did calisthetics, took endurance tests, and competed against one another for the spaces in the first boat. You may feel ready to row a marathon—but the race will only last about six minutes. And it will feel like an eternity. Victory, Proust once remarked, belongs to the antagonist who knows how to suffer one quarter of an hour longer. In crew it's one quarter of a minute longer.

You have been working for months on the rhythm of the stroke, moving exactly in phase with the person in front of you. If you unstick your eyes from her back, you will get out of phase with everyone else, slow the boat down, and possibly lose your oar. You cannot afford to stop concentrating for an instant. The psychological stress is enormous.

In tennis, baseball, and other coordination sports, technique counts more than strength. At some point in training, you are as fit as you can get, but you can always work on your movements and coordination. Crew is the opposite. There is only one movement to learn, but strength is of the essence. It's a brute-force sport, probably the best exercise you can get sitting down.

Turning Diversity Into Success

The way I joined crew was not atypical; only a few M.I.T. rowers or coxswains come in knowing anything about row-

"It's a brute-force sport, probably the best exercise you can get sitting down."

ing. Some were high school athletes who decided to try a new sport in college, but a surprising number choose crew as a first sport. "I decided I wanted to do something different here, something competitive. I didn't want to graduate thinking of M.I.T. as just problem sets," says Mary McCartney, '84, who joined crew as a senior.

Yet despite the apparent handicap of inexperience, the Engineers hold their own against boats containing athletic scholarship holders and national-level high school rowers. "The great thing about crew is that everyone starts equal, and it can become an individual sport," says Ingrid Klass Gorman, '76, one of the first M.I.T. women's crew captains.

"Harvard will have two or three schoolboy champions in their boat, and they know they are good," a freshman lightweight coach wrote in 1966, instructing his successor to convince his charges they could beat Harvard—and they would. "There is no such animal as an overconfident freshman crew," he observed.

"Took Off . . . Like a Scared Spider"

Crew was more important to Ingrid Gorman than anything else at M.I.T. She worked at Draper Laboratory to pay her way to the national championships after she graduated. Recalling the struggle to build a team, she said, "When I joined, we were a ragtime crew. Coach Dan Ernst never knew who would show up for each race." The women had to fight for decent boats, varsity status, and even a locker room of their own. "That came after the athletic director discovered some of the women showering with the men," Gorman said. "In 1974 we got a new coach. John Wilson insisted on good attendance and pushed very hard to get the women's crew coach paid."

Perhaps the ultimate success story in M.I.T. crew is the 1954 men's varsity lightweight eight who won the Henley. The annual regatta at Henley-on-Thames in England is rowing's equivalent of the World Series, the Super Bowl, and Wimbledon all rolled into one. The Engineers' victory was especially sweet because they only barely qualified for Henley by winning a tough race at the end of a bad season. Reunited at this year's crew banquet, 30 years after the win, they told the story.

Their last chance to redeem a lacklustre season came at the Eastern Sprints, the end-of-the season confrontation of the 10 major rowing powers in the northeast, as far south as Navy and west to Cornell. The M.I.T. coxswain, Jerry Waye, '54, had laryngitis that week and couldn't speak, let alone yell. Although the race seemed lost before they began, the crew practiced starting in silence (starts usually involved a complicated series of commands from the coxswain) and worked out a code: Waye would pound the wooden handles of his steering lines on the side of the boat to tell them to slow down their movements and he would only try to talk if they were gaining on the other boats.

"We took off from that starting line like a scared spider," captain William McTigue, '54, recalled at the banquet. "Then we passed Navy, Jerry croaked at us, and suddenly we got good. We put on a half-mile sprint and showed them all the way to the finish line. It was over two miles back to the boathouse and we sang all the way. And as we passed Navy coming back to the dock, we heard one of their rowers say, 'Look at that! Every one of them a brain!' "

The other rowers were Robert Sawyer, '56, Gordon Burrer, '55, Robert Buntschuh, '55, Robert Wilkes, '55, Leonard Gallagher, '54, Larry Holmes, '55, and Val Skov, '55. "I think we were not a great crew technically, but we had a lot of that good old desire to win and we were M.I.T. rowers," McTigue said. "There is a photo of us going under a bridge at Henley that shows the only reason the boat balanced was that our errors cancelled."

McTigue characterizes the M.I.T. school of rowing as "analytical." Coach Jack Frailey, '44, cased the course and told his men how far ahead they'd have to be at a particular point to win. They stayed far ahead throughout the course, and didn't find out until afterward that Frailey had deliberately overestimated the distance. "I realize now that Jack was a shrewd psychologist," one of the rowers said.

"I think getting into Henley was much more fun than being there," McTigue said. "I have more memories of long rows to Watertown than I do of race days. Both were equally satisfying. You have to search out those moments of excellence in practice, but they are just as valuable as the ones you get a prize for." □

Threatened Elsewhere, They Thrive at M.I.T.

Fraternities Meet Challenges of Upscale Neighbors, High Costs, Shift in Student Balance

by John Piotti, '83

Editor's Note: This article focuses on fraternities, sororities and other independent living units which are members of the IFC and which have a residential function. There are also a number of service and honorary fraternities and sororities.

When Colby and Amherst Colleges voted earlier this year to abolish their fraternities, a spotlight was suddenly focused on fraternities everywhere. The M.I.T. fraternity population responded with interest, but no real concern. Similarly, M.I.T. administrators approached by campus and community media asserted that our fraternities are in no such danger.

None of this comes as a surprise. For over a century, fraternities at M.I.T. have contributed to the intellectual and social life of the Institute and promoted high standards of personal and community responsibility. While other universities have found it increasingly difficult to justify fraternities on their campuses, M.I.T. has been able to work with alumni and undergraduates to strengthen and even expand its independent residence system.

Today, the Interfraternity Conference (IFC) represents not only chapters of national fraternities, but local fraternities (three of which are co-ed), two non-Greek living cooperatives (one co-ed, one all women) and—our most recent addition—a chapter of Alpha Phi national sorority. In total, 1,500 students, more

Above: Mark Sorrells, '83, like his brothers at Alpha Tau Omega, reaches into the community with activities like this Halloween party at Tutoring Plus.

The Institute relies on fraternity members to operate a physical plant worth more than $60 million.

than a third of all undergraduates, belong to one of the 34 groups.

What is surprising, to me at least, is that M.I.T. maintains a high level of administrative support without control in a system where each house is owned independently, and every group is free to develop a high degree of autonomy.

It is precisely this special relationship that lets our fraternities succeed. The self-management of an M.I.T. chapter house—providing for the needs of 35-50 young men—develops high levels of responsibility in fraternity members which would be threatened by heavy-handed control. At the same time, M.I.T. relies on the fraternity system to operate their houses—a physical plant valued at more than $60 million—and is naturally concerned with the sound management of this enormous asset.

But even though no administrator would suggest abolishing our fraternities, the time has passed when the success of an undergraduate chapter can be measured solely by its contributions to campus life and Institute housing. Like it or not, most fraternities are part of the off-campus community, and their survival now depends, in part, on their relationships with their neighbors. At the same time, other problems may pressure M.I.T. to alter its current balance between fraternity support and control.

Although many of these pressures have been mounting for some time, it is only in the past two or three years that they have markedly affected the way M.I.T.'s fraternities operate. As a house and IFC officer during this period, I have been both observer and player in a time of real change in the fraternity system.

Costs Always An Issue

Since I pledged Sigma Chi in 1979, I have seen tuition grow from $5,400 to more than $10,000, which has had a major impact on the operations of the fraternity system and on the priorities of fraternity members.

Fraternities, as a whole, continue to be less expensive than dormitories, owing in part to the savings associated with self-management. But the development over the past decade of attractive and abundant campus housing, coupled with cost-induced loss of many of the amenities once associated with fraternity living—fine furniture and draperies, washed linens, three prepared meals a day—has increased the competition between dorms and frats to attract new members.

I see a real risk that our fraternity houses will be pushed to reduce room and board even further, at the expense of the long-term maintenance of the physical plant. To counter this threat, a few house corporations first set a competitive rent and then solicit alumni donations to help offset the costs of physical upkeep and renovation.

Students More Conservative

Rising costs are also motivating many incoming students to attempt to graduate ahead of schedule. And in general, students in the 1980s have a more conservative outlook. They tend to be much more "pre-professional," as evidenced by the dramatic moves away from the fields of science toward engineering, and are reluctant to take time away from academics. All this adds up to difficulties for fraternities in assigning major responsibilities.

At the same time that M.I.T. was raising tuition, it was also cutting back on student services, and in the 1982 reorganization of the Office of the Dean for Student Affairs the position of full-time fraternity advisor was dropped. I knew firsthand the importance of an advisor who could identify resources within the Institute, provide continuity from year to year, and rally support for the fraternity cause, and I saw a weakening of the relationship between fraternity officers and M.I.T. administrators over the past two years.

Although M.I.T. recently announced that it will create another fraternity advising position, I question whether the new advisor's role will remain primarily supportive, as in the past. M.I.T.'s growing concern over alcohol use and personal conduct, and over the lawsuits which could hold the Institute liable for related problems, may promote a program aimed at establishing "codes of conduct" within houses in conjunction with a system-wide alcohol and drugs policy.

Women Bring Change

Recent trends in M.I.T. admissions will also continue to influence the character of our system. As the percentage of incoming female students increases, the traditional men's fraternities will have to attract an even greater percentage of the new male students. (Already close to 50 percent of the first year men join fraternities.) Eventually, some groups may be forced to disband or convert to co-ed living arrangements.

At the same time, women from the all-female groups and the co-ed houses are making their mark: at present, two of the eleven IFC officers as well as three of the six members of the IFC Judicial Committee are women.

But having national sororities at M.I.T. could bring other changes. Those of us who were involved in the review of Alpha Phi and other groups prior to selection were struck by their alcohol prohibition in chapter houses and their imposition of other restrictions. Should the Institute increase the number of sororities, it will have to establish a Panhellenic Council (an "IFC" for sororities), bound by strict national rules which differ greatly from M.I.T. practices, particularly rush.

Support without control has been a unique feature of M.I.T.'s relationship with its fraternities.

A more immediate concern, however, is where to house new groups. Alpha Phi, for instance, still doesn't have a house. While M.I.T. hasn't targeted land of its own for fraternity building, it recently curtailed the search for existing property in residential Boston because of political and community uncertainties.

Condominium Meets Fraternity

That uncertainty is one more consequence of the dramatic change affecting the Boston-based fraternities—the shift in the character of their neighborhoods, where luxury condominiums have replaced many modest apartment buildings and student residences. Our new neighbors have a considerable personal and financial investment in their property and little tolerance for fraternity noise. They may complain vigorously to city, neighborhood and M.I.T. officials about activities like passing a football out on the sidewalk or a weekend party—activities which went on relatively unnoticed for years.

In more than one case, a thin wall is all that separates a fraternity from its condominium neighbors, who find a heavy tread on the stairs, the frequent closing of the front door or the loud playing of a radio to be an intolerable disturbance.

As fraternity residents, it is often difficult enough to curtail our weekend partying or the throwing of frisbees on a warm spring day, let alone to learn to tiptoe up the stairs. But these changes in fraternity lifestyle are being imposed out of necessity. Altruistic reasons aside, good community relations are essential to our future existence. Community grievances could pressure the city to revoke fraternity "lodging house" liscenses, which are issued on a discretionary basis. Moreover, the Neighborhood Association of the Back Bay (NABB) has just recently formed an "Action Committee," with the purpose of raising funds "to help defray cost of legal expenses of cases which the [NABB] Board feels are important to our neighborhood as a whole." That committee now focuses on issues like cable TV, but it could turn its attention to a class action suit against fraternities.

To allay that threat, many chapter houses are working hard to establish themselves as assets to the community. Fraternity officers can be found visiting neighbors, serving on the NABB Board, encouraging local political activity (one of my brothers from Sigma Chi recently orchestrated the election of 18 fraternity men to the Back Bay Ward Republican Committee and a friend from another house is running for State Representative), coordinating community service projects (including the ongoing cleanup program at Boston's Public Garden), and policing our own parties.

Alumni Involvement Vital

At the same time, we are under a lot of pressure to practice long-term facility management and financial planning. This requires both alumni and undergraduate officers who are developing the resources to meet needs before crises develop.

Every fraternity alumnus can aid this process, by keeping in tune with the changing demands of chapter life, by responding to house corporation fundraising, and by earmarking M.I.T. donations to the Independent Residence Development Fund (I.R.D.F.). Moreover, fraternity alumni living in Back Bay and Cambridge can become directly in-

CHINA ALTMAN

Above: Fraternity members spent an April Sunday winning friends by cleaning the Public Garden. Opposite: Much credit for the prize-winning effectiveness of the M.I.T. Interfraternity Conference goes to its communications efforts, including the publication **InFocus,** *whose editors are shown in a light moment.*

Political action is gaining appeal, and one fraternity man is on the ballot for State Representative.

volved in their communities, bring the fraternity viewpoint to neighborhood associations and local political campaigns.

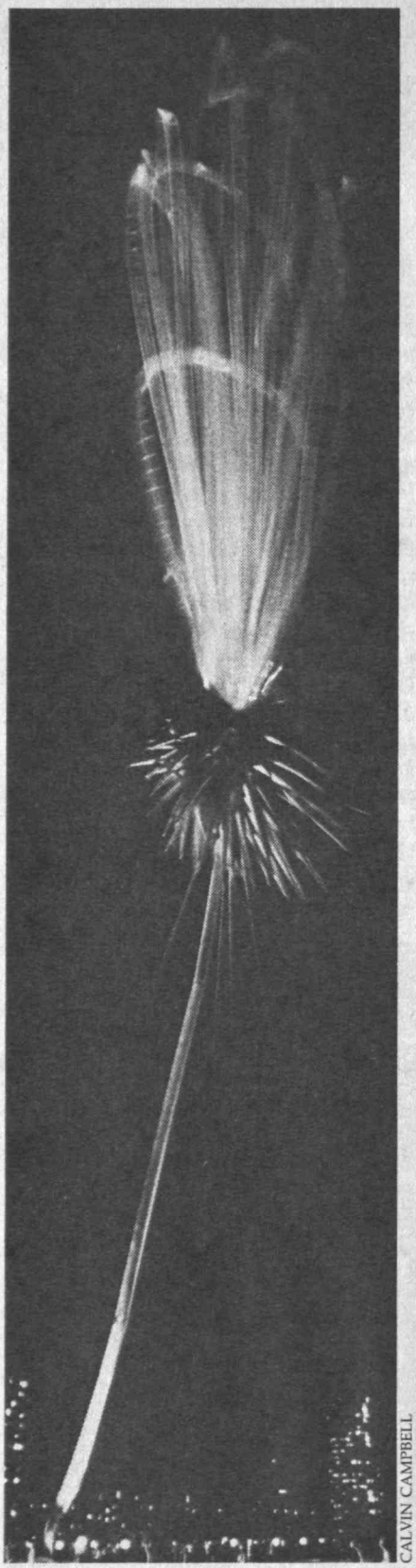
I have no doubt that undergraduates and alumni will meet these challenges, demonstrating again their concern that the quality of the fraternity experience be preserved.

Excellence Recognized

The exceptional qualities of M.I.T.'s fraternity system are recognized off campus. Our IFC received the 1984 Lunsford Award from the Northeastern InterFraternity Conference, recognizing it as the most outstanding in the approximately 60 members of the 11-state region (this in spite of the fact that M.I.T. has one of the smaller IFCs in the region). As well, in a performance not atypical for M.I.T., my own chapter has won Sigma Chi's highest national award for the past eight years.

But to most of us, these awards are not the heart of the matter. It is our committment toward one another that is important. Our success stems from the bonds we form with people of different backgrounds and outlooks. Having close friends in almost every fraternity at M.I.T., I have seen that same spirit in all. Though this feeling is not unique to chapters on this campus, there must be something in the rigor of our work, the maturity and independence of our students, the support of our alumni, or our four-year "in-house" system which is unique. Fraternities at M.I.T. have something special which—according to the media reports—an observer couldn't have found at Colby or Amherst.

JOHN PIOTTI is in his fifth year, seeking dual bachelor's degrees in ocean engineering and political science and a masters in ocean systems management. He has served as president and rush chairman of the Alpha Theta chapter of Sigma Chi, as chairman and vice-chairman of the M.I.T. InterFraternity Conference, and as co-chairman of the Expansion Committee which guided the formation of M.I.T.'s first national sorority. At the 1984 Awards Convocation he received the Frederick Gardiner Fassett, Jr. Award for his dedication to the ideals of the M.I.T. fraternity brotherhood as well as one of five Karl Taylor Compton Prizes, which recognize exceptional efforts to promote achievement and good citizenship within the M.I.T. community.



CALVIN CAMPBELL

Otto Piene: "Blue Star Linz" Sky event for the 1981 Sky Art Conference, Cambridge, Mass.

The Center for Advanced Visual Studies: Where Art Comes Off the Wall

by Marty Carlock

You still think of art as something to hang on the wall or put on a pedestal, do you? Something that you can buy, keep, enjoy at your leisure, see appreciate in value, sell, pass on to your heirs? If so, the people at the M.I.T. Center for Advanced Visual Studies have a few things to show you.

Such as: sky sculptures—gigantic airborne flowers, birds, and rainbows made of parachute fabric . . . steam sculptures—mist and fog on which laser drawings are projected . . . participative video art, wherein the viewer can interact with a laser video disc . . . holography—3-D stuff . . . light installations—environments created by light alone. And space art, utilizing Skylab, shuttle, and satellite photography.

Art, science, and engineering coalesce at CAVS, an experimental laboratory for artists, an aesthetic think-tank that is as much a testing ground for new ideas as any other laboratory of more conventional content.

CAVS limits itself by having one general rule of thumb: the art produced there must depend on the tools of contemporary technology. The idea is to tap the scientific and engineering know-how of M.I.T. to create new forms and works. As CAVS Fellow Joe Davis says, "If the aim of the artist is to tell the truth, and if I use technology 500 years old, how can I tell the truth for my time?"

Accordingly, projects pursued by CAVS Fellows include some with intriguing titles: "sun sculptures"—cybernetic art works under water; "inquiries into the biomirror"—symmetries of nature, specifically mirror reflection and its role in brain dynamics; "project to change lightning color storm modification"; and "laser stone carving manipulation programming."

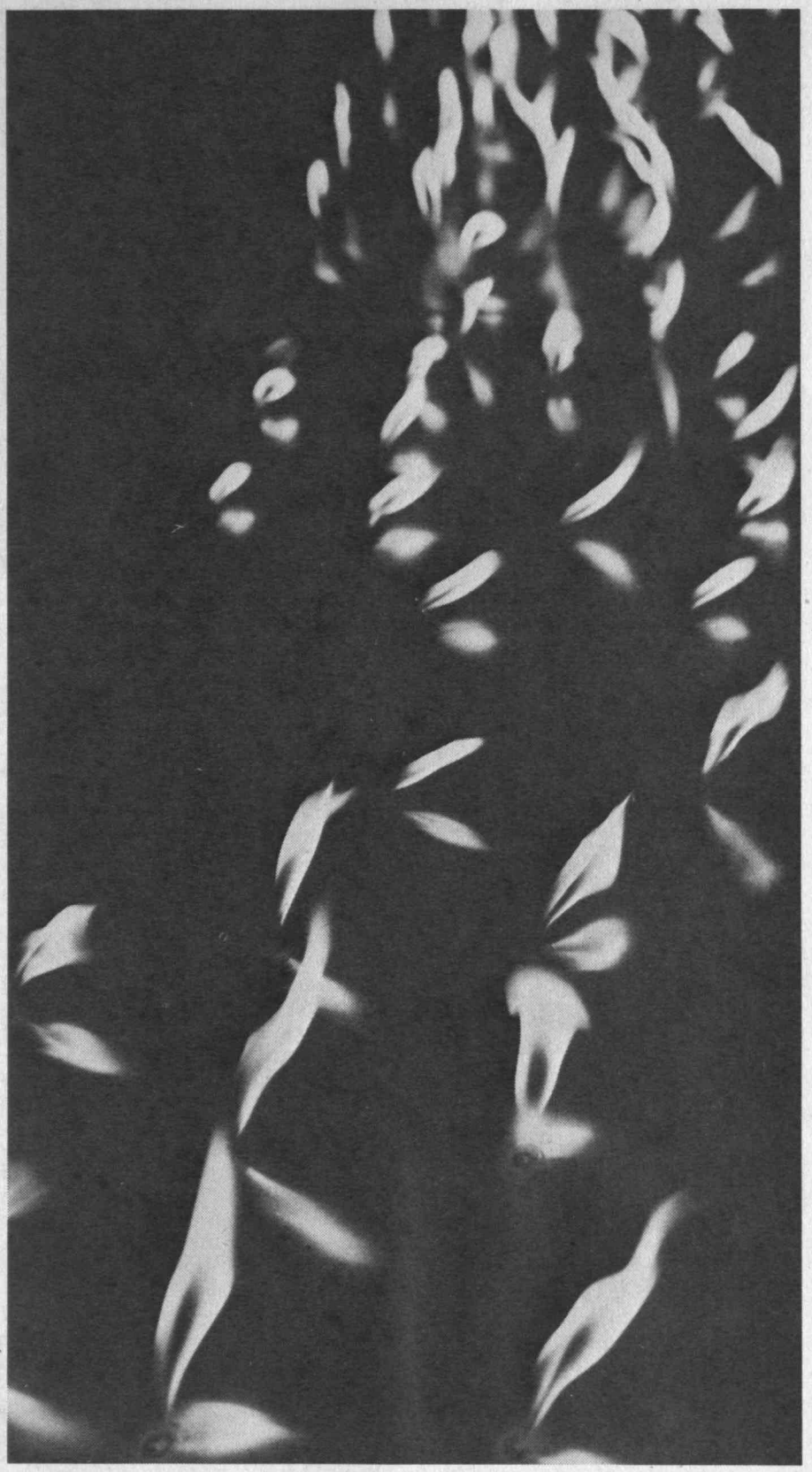
. . . an experimental laboratory for artists, as much a testing ground for new ideas as any other laboratory . . .

Everywhere On and Above the World

It isn't easy to see the Center's work. For one thing, its fellows produce their art all over, and out of, the world—very little of it at M.I.T. For another, a good deal of it is performance art, what the art world used to term "happenings"—dazzling visual events that are temporary, can be documented on film or video tape, and can be remembered and wondered at but not bought, sold, or collected.

This summer, however, there will be some opportunities to see the fruits of the Center's work. Harriet Casdin-Silver's holography is currently in London, Frankfurt, and New York. Musician Christopher Janney has just finished installing a "sound piece" at the Dallas Museum of Art. Video artist Bernd Kracke has projects coming up in Dusseldorf and Linz. Lowry Burgess has been tapped to do a large environmental work for Earthwatch in the Southwest (site to be determined). Betsy Connors has a grant to produce 12 new works for cable television; a Beth Galston sculp-

Gyorgy Kepes: "Flame Orchard"
In collaboration with Mauricio Bueno, William Walton, and Paul Earls
Sound-animated gas flames, 1972



NISHAN BICHAJIAN

"I Design Celebrations," says Director Otto Piene

ture will be installed in a Cambridge park shortly. Boston audiences saw the Center's multimedia mini-opera "Icarus" in May, and New Englanders were treated to a Piene sky-sculpture as part of a performance production at the Guggenheim Museum early this month.

On a more intimate scale, New Englanders will have a chance to sample a CAVS item during the next 18 months, as the "Sky Disk" traveling exhibit visits museums, libraries, and college campuses. Developed by Vin Grabill and Rus Grant with Digital Equipment Corp., it's an artwork to be played on Digital's IVIS. The viewer can interact with the work.

Woods Hole, Mass., is to be the site in September of an all-day inflatable sculpture performance starring a mammoth polyethylene jellyfish. Initially waterborne, the 110-foot sculpture will be helium-lifted into the evening sky, where phosphorescent materials and spotlights will give it the illusion of bioluminescence. If successful, it will be spectacular; if not, it will probably be fun anyway. The jellyfish's designer, Jonathan Goldman, is a candidate for a "Miz-Viz," or master of science in visual studies, the CAVS graduate degree.

Center artists are not hung up on success or failure. CAVS director Piene likens his cohorts' work to that of scientific researchers in any field. "You never know whether a scientific experiment is worth doing until you do it," he points

WALTER DENT

Paul Earls, Otto Piene, and Ian Strasfogel: "Icarus" Opera for the 1983 Sky Art Conference and International Horticultural Exposition, Munich Pasiphae (Diane Curry), Daedalus (David Holloway), and Icarus (Norbert Fischer

ELIZABETH GOLDRING

Otto Piene: "Minor Black Rose" Sculpture for the "Festival of the Future," 1982, DeCordova Museum, Lincoln, Mass.

out. "You cannot predict the results, and sometimes the experiment fails."

Logistics for a Polyethylene Jellyfish

Odd though it may sound to outsiders, Goldman's jellyfish sculpture is right in the mainstream of CAVS work. It follows directly in the genre of sky art fostered by Piene. It is inspired by its environment—Goldman, who grew up in Woods Hole, chose the jellyfish form because "I wanted to do something site-specific." It's designed for spectator participation, and it demands the kind of collaboration from technical experts that most CAVS projects need.

To begin with, Goldman had input from researchers specializing in coelenterates—jellyfish and polyps—at Woods Hole Oceanographic Institution. To help design and test models of the sculpture, he has enlisted members of M.I.T.'s Department of Earth, Atmospheric and Planetary Sciences. Goldman hopes to add sound to the performance—music that would be generated by oscillators when light strikes photoelectric cells—and for this he's working with photovoltaics experts in the Department of Electrical Engineering and Computer Science.

The Coast Guard has promised to monitor the events of performance day, September 15. The artist hopes to drum up support from townspeople, especially boatsmen, to help maneuver the performance piece about the waters. He plans to approach harbor officials for use of docks as viewing sites. He has even lined up students at the Children's School of Science in Woods Hole to help work on the project. In performance art, as in theater, logistics and planning loom large.

Taming Technology with Art

In a sense the Center for Advanced Visual Studies is the art department at M.I.T. But, despite the fact that it offers a couple of classic drawing courses which are oversubscribed semester after semester, that's a simplistic description.

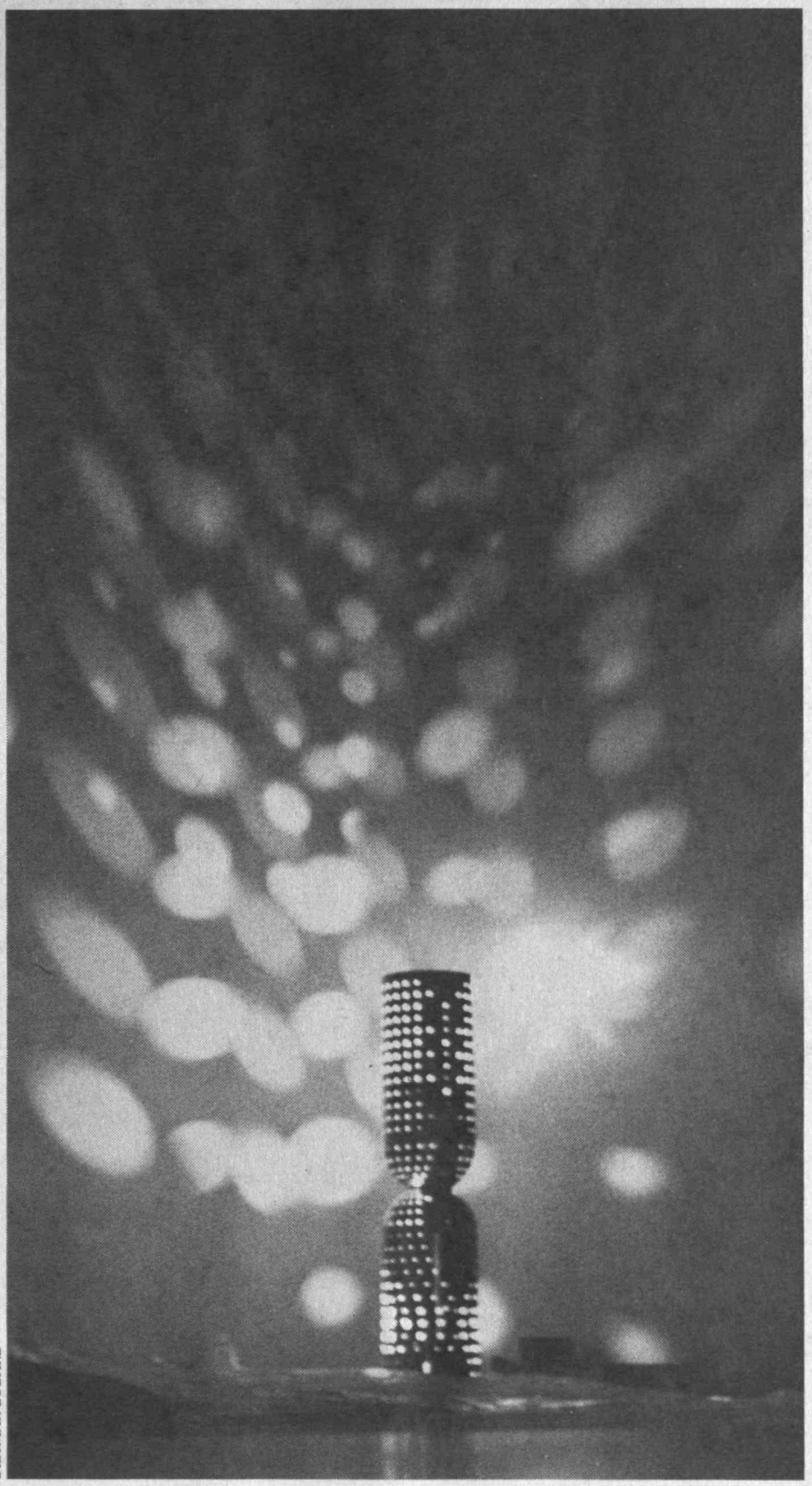
CAVS was the concept 20 years ago of Gyorgy Kepes, then professor (now Institute Professor Emeritus) of visual design in the Department of Architecture. Kepes believes he introduced the environment to art; as early as 1951 he urged cooperation between artists, scientists, and technical thinkers.

"I felt that dangerous blind alleys had developed for the artist, in that he had become disconnected from both the social and the ecologial environment," Kepes recalls. "The Center was to be a focus . . . where the artist could explore the most advanced forms of scientific technology in order to produce a work of art that enriches the environment."

By "environment" Kepes meant the

"Art is a shaping of life, like a genetic coding."—Emeritus Professor Gyorgy Kepes

Otto Piene: light sculpture for "Icarus" 1982 Sky Art Conference, Bruchnerhaus, Linz, Austria



DIETMAR LOEHRL

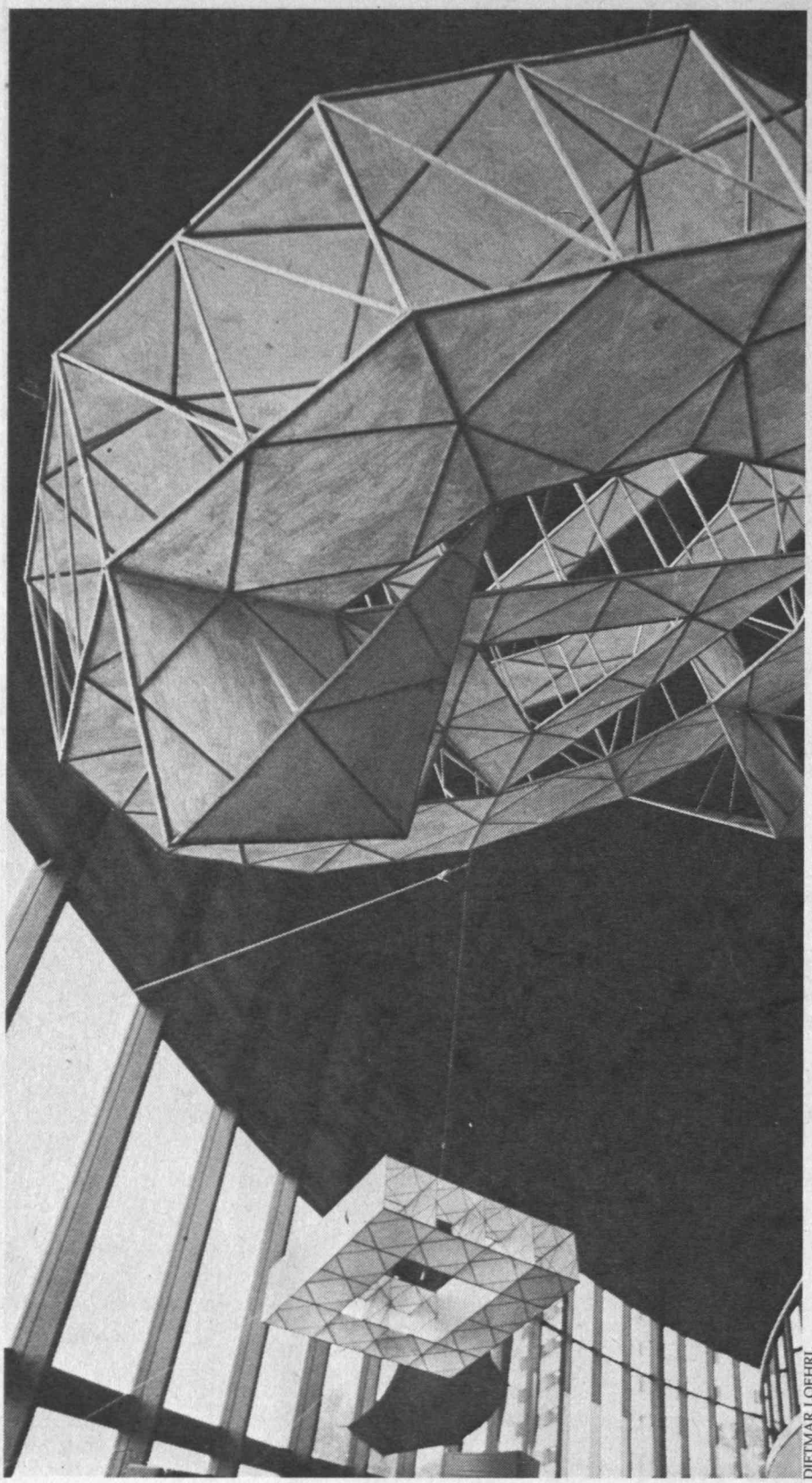
urban landscape, where "wild growth makes our cities seem beyond human control." And in fact, CAVS' present emphasis on performance art rather than the more permanent environmental art is not to Kepes' taste.

The Center remains true, though, to Kepes' vision in its emphasis on turning technology to humanistic purposes. Kepes was troubled by technical proliferation; it appeared that technology would take over human life. By using technology for the creation of art, artists might be able to tame it. "Art is not play," Kepes says. "Art is a shaping of life, like a genetic coding."

Professor Kepes presented his idea to the Institute in 1965 and the Center was established two years later. One of Kepes' first applicants for a fellowship was a German painter and maker of "happenings," Otto Piene.

Piene had been working with lights and moving discs to create a kinetic art he called "light ballet." At M.I.T. Piene conceived and demonstrated a different sort of light ballet—larger, less structured, and outdoors. He cut commercial polyethelene tubing into long skinny pieces, sealed the ends, and inflated the tubes. Tying one end down, he let the tubes, a hundred feet long or more, float and snake in the evening breeze, lighted by spotlights. The next day he found a note tacked to his door: "Good show!"

That experiment led to a series of rain-



DIETMAR LOEHRL

Left:
Jose Marie Yturralde: Kite
1982 Sky Art Conference, Bruchnerhaus, Linz, Austria

Right:
Paul Earls: "Three Period Pieces"
Dances by the New England Dinosaur Dance Company
Inflatable sculptures by Otto Piene
Lobby 7, M.I.T., Alumni Day, 1975

bows, tubing with both ends tied down: multiple arcs over Pittsburgh in 1970, a 1,600-foot rainbow in the Olympic colors at the Munich games, another over the Charles River Basin, and another which he set afire at sea off Hawaii.

From there Piene went on to flower-forms—gigantic chrysanthemums and anemones, then to stars, figures, roosters. Given those antecedents, a flying bioluminescent jellyfish doesn't seem so far-fetched.

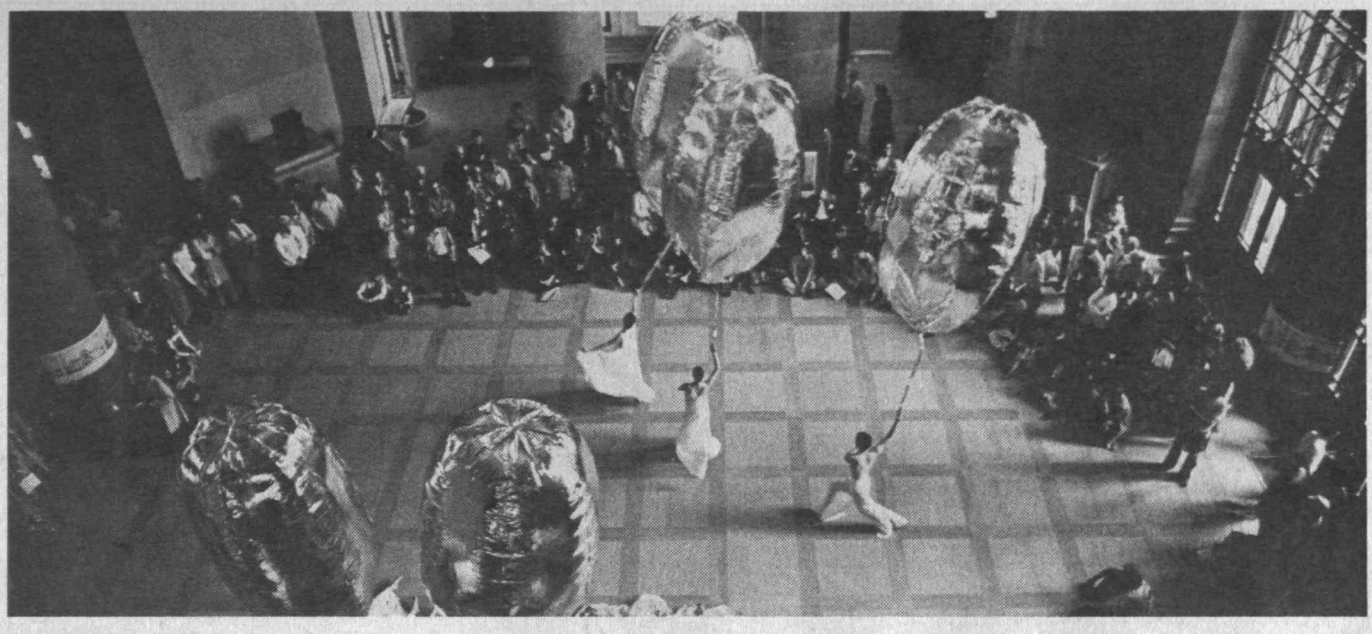
Flickering, Blue-Green Images

My interest in CAVS was whetted by attending a few "Artists Speak" sessions last spring, and I wanted to see some CAVS work in action. I began asking the artists when there'd be something to see. Everybody shrugged. I had just missed two major performances for First Night, Boston's New Year's celebration. Now everybody was working toward the Sky Art Conference slated for last fall in Munich. Somebody might do an event for the Cambridge River Festival; then again, they might not.

Finally one night, as an afterthought, Fellow Vin Grabill said, "Oh yeah, there's going to be something tomorrow night in the alleyway out back. Lasers." What time? Whenever it got dark. Maybe 7:30.

When I arrived I discovered mist and flickering blue-green images.

Joan Brigham, a former fellow who specializes in steam sculpture, was



standing nearby. (Former fellows never go away. They're welcome to continue collaborating, and they do.) Brigham explained that the lasers and mist were a trial run for a water sculpture planned for the New Orleans World's Fair.

The argon-krypton laser would project drawings through several water screens to a wall 100 feet away. The size of the water droplets is crucial, and Brigham experimented with 30 kinds of nozzles before settling on crop-spraying equipment. She learned steam engineering from the Mechanical Engineering Department. "Lasers show up better on mist; film images look better projected on steam," she explained. Other technologies have been used for other projects. Brigham studied solar power applications and has built some sun-powered kinetic sculptures. Other CAVS artists have worked with neon sculpture, strobelit vibrating sculptures, manipulation of sunlight, and environment-sized stone-and-earth design. Nobody at CAVS is working in those media right now; telecommunications, music, holography, urban planning, and space art occupy the current Fellows. There's some use of computer-generated art, and computers are used often in the design of projects.

Video art is a big item at CAVS. A public saturated with conventional television images finds it hard to visualize video's possibilities, so CAVS video needs to be seen. But here's a sample.

Israeli video artist Dov Eylath projects on the television monitor the face of another performance artist, Joan Bean. "We originally did this live, before an audience," he explains, "—the two of us sitting before two cameras with the images appearing on three-screen projection." On screen Bean begins talking more or less to herself and slowly applying a cream to her face. Where the cream covers her visage, another face appears—underneath? behind? instead of? The other mouth begins answering her, and a dialogue about identity ensues. Soon only Bean's mouth and eyes appear as dual features with the other face, and when she closes them the other face, Eylath's, is left inside the frame of Bean's hair.

Or consider the use of slow-scan video by a group including Grabill, Sarah Dickinson, Aldo Tambellini, Rus Gant and Kracke. Slow-scan is something like a live video slide show. A video camera shoots the subject, but the scanner grabs a still image every eight seconds and transmits it line by line over telephone circuits. At the other end the image builds up, line by line, and moves onto the monitor screen, a new image every eight seconds. Slow-scan's primary advantage is that it's cheap to transmit, because it is sent over long-distance phone lines. During Sky Art 3 this system was used to send slow-scan productions to Munich audiences.

Joe Davis is working on another application for slow-scan—remote manipulation of materials. He sits at a video screen in the Visible Language Workshop at M.I.T. watching the image of a rock in a laser lab in Wisconsin. He draws glyphs that are computerized, transmitted to Wisconsin, and carved into the rock by a computer-controlled laser as Davis draws them. Church Metal Spinning and Fabricating Co. in Milwaukee, where the laser and rock are located, sees future commercial applications for remote control of lasers. Davis' motives are simply artistic/synergistic.

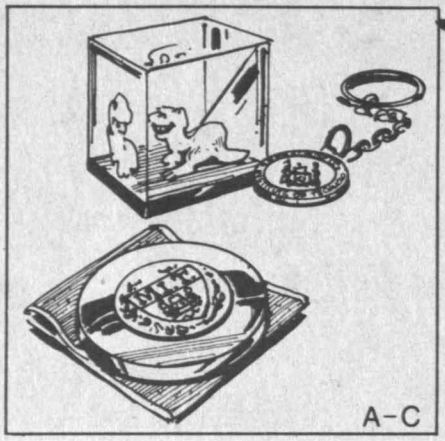
The Center has three reservations with NASA to put art payloads into orbit. The first should come this year: Davis is assembling a system that will paint the sky with artificial auroras over the northern hemisphere.

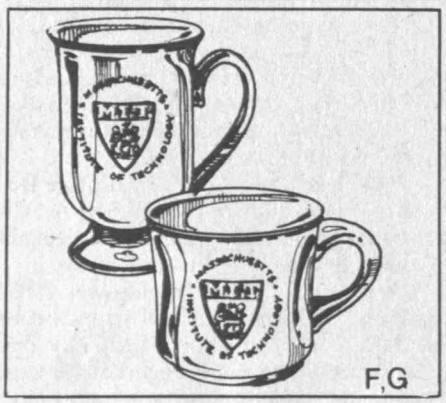
Piene's interest in sky sculpture led to his organization of the first Sky Art Conference at M.I.T. in 1981. Now he's planning a fourth such conference in the desert outside Los Angeles for 1985 or 1986, with the principal event being a definitive production of the sky opera "Icarus." The work began as an experimental sketch; singers actually flew—aided by helium balloons—among Piene's helium-filled polyethlene loops. In a second version for Sky Art 1 Piene and composer Earls called on video magic to make the hero appear to fly. The desert location "will give us all the sky and all the time we've ever wanted," Peine says.

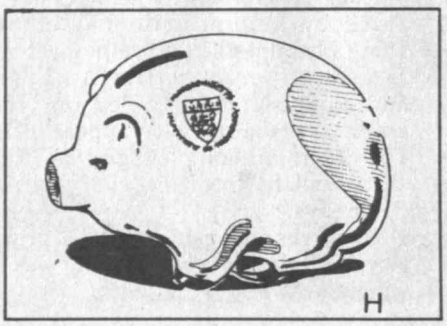
Piene was once asked what his profession is. "I design celebrations," was his simple answer.

"On screen Bean begins talking more or less to herself . . . then another face appears, and the other mouth begins answering her . . ."

M.I.T. Insignia







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B. **SOLID BRASS PAPERWEIGHT** with M.I.T. seal engraved. **$15**

C. **INSIGNIA KEYCHAIN** of brushed pewter. **$6**

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E. **GLASS BEER MUG** with platinum M.I.T. insignia seal. **$6**

F. **M.I.T CERAMIC IRISH COFFEE MUG.** Gold trim, handle and M.I.T. seal. **$15.50**

G. **M.I.T COFFEE CUP.** Ceramic with tri-color insignia seal. **$5.95**

H. **CERAMIC PIGGY BANK.** Creamy white, gold trim ears and hooves. Scarlet. M.I.T. seal. **$12.95**

J. **BRUSHED ALUMINUM MUG** with pewter insignia seal and clear glass bottom **$17**

M.I.T. ACTIVEWEAR BY CHAMPION

K. **M.I.T. CREWNECK STYLE SWEATSHIRT.** Cotton / acrylic fleece in scarlet / white seal or grey / scarlet seal. Adult sizes S, M, L, XL. **$16** (Not Shown) Hooded Sweatshirt with pouch pocket, sizes S, M, L, XL. **$20**

L. **M.I.T. T-SHIRT** with contrasting banding and insignia seal in grey or maroon, adult sizes S, M, L, XL. **$8.** Youth sizes XS, X, M, L. **$7.**

M. **M.I.T. BEAVER T-SHIRT** in white with scarlet trim. Cotton / polyester blend, adult sizes A, M, L, XL. **$8** Youth sizes XS, S, M, L. **$7.**

HARVARD COOPERATIVE SOCIETY **the Coop**

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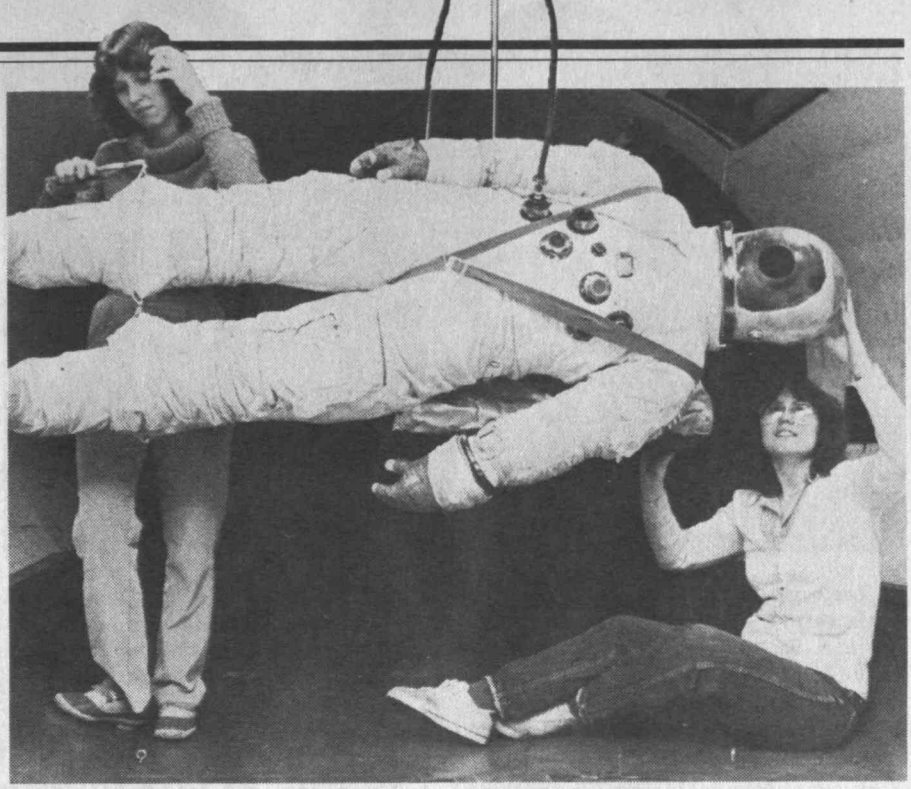
Under the Domes



CALVIN CAMPELL

Why test in a wind tunnel a suit designed for use in the vacuum of outer space? Answer: the space suit will soon be tested in NASA's underwater weightlessness simulator, and to make that test effective it's necessary to know the drag of water against the suit. That, in turn, can be simulated by a low-speed wind. Hence this test in the Wright Brothers Wind Tunnel by Diane M. Peterson, '84 (left), and Laura A. Loechler, '84—part of a continuing program in the Department of Aeronautics and Astronautics to study efficient methods of working in space.

Athena Progresses

Two computer makers have added new leverage to Project Athena, the Institute's effort to bring coherent computer experience to all M.I.T. students:

□ Digital Equipment Corp. has agreed to sell the Institute a large number of DEC personal computers for resale to students and staff at a substantial discount.

□ Codex Corp. has joined Athena to help develop the campus-wide network that will integrate the 2,600 computers and work stations that will ultimately be involved in the project.

Codex will work on what will become the principal computer network on the campus, tying into the new equipment for Project Athena as well as student, laboratory, research, and administrative systems already in place. Professor Steven R. Lerman, '72, Athena director, calls this networking "a key technical and educational objective, . . . a prerequisite for the easy sharing of programs and data and the accumulation of useful educational software." To implement its contributions, Codex has assigned three of its staff to the Athena project. □

Dean for Minorities

Janice R. Cooper, assistant dean of the college at Brandeis University, will arrive at M.I.T. this summer to be assistant dean for student affairs. She succeeds Mary O. Hope, whose resignation from M.I.T. was widely lamented by members of the Black Student Union and the Black Alumni of M.I.T. (BAMIT).

Ms. Cooper studied at Wheelock College, and she holds a master's degree (1975) from Antioch College's Institute of Open Education, Cambridge. Prior to her work at Brandeis, Ms. Cooper was a resource councelor for METCO, the alternative program in which black students are enrolled in predominantly white schools in the Boston suburbs, and she was guidance counselor at Wellesley Junior High School.

Ms. Cooper's selection was made by a search committee of four students and four members of the faculty and staff from a total of nearly 140 applicants. □

Admission Post Open

Peter H. Richardson, '48, will step down as director of admissions, a post he has held since 1972, to take early retirement as of Sept. 1. He and his wife plan to move to Vermont.

Vice President Constantine B. Simonides, '57, announced that a search for Mr. Richardson's successor will be launched immediately. The post will be advertised nationally, and an advisory committee chaired by Sheila E. Widnall '60, Professor of Aeronautics and Astronautics, has been named to assist in screening applicants. □

J.R. Cooper

P. Richardson

Saxons Have a Taste of Big Apple Hospitality

Against the marine backdrop of the American Museum of Natural History's Hall of Ocean Life, almost 500 alumni, spouses, and friends gathered on April 24 to greet Corporation Chairman David S. Saxon, '41, and his wife Shirley.

Wearing the pre-war freshman tie, Saxon reminisced about his class—one of the few, he boasted, to win Field Day as both freshmen and sophomores. He also shared his view of the future of "the marvelous institution from which we all graduated." Recognizing present financial constraints, Saxon warned that "you cannot do work of absolutely the first rank on the cheap."

But the evening reception, organized by the M.I.T. Alumni Center of New

As they neared the first anniversary of their return to M.I.T., Dr. and Mrs. David S. Saxon were honored by alumni in the New York City area at a gala reception at the American Museum of Natural History. The box—presented to the Saxons by Angus N. MacDonald, '46 (right), chairman of the event—proved to contain a memento of the "big apple" in Steuben glass. Dr. Saxon, who graduated in physics with the Class of 1941, is chairman of the M.I.T. Corporation.

York, was designed mainly for social relaxation. A string quartet, consisting of Stephanie Weyfield, '82, Philip Shu, '87, Jeff Bigles, '87, and Wellesley freshman Renee Jacksy, played airs from Mozart, Telemann, and other composers. Cocktails and gourmet hors d'oeuvres circulated freely, spoiling many a dinner appetite. And guests from the alumni clubs at Fairfield County, Hudson Valley, Long Island, Northern New Jersey, Princeton, and Westchester County chatted with old classmates, discovered new friends, and lined up to greet the chairman and his wife. □

Admissions: Weighing Sciences vs. Diversity

The number of U.S. high schools without adequate programs in physics and chemistry is apallingly large, and so therefore must be the number of high school students who have no opportunity to study those subjects.

And if physics and chemistry are required for college admission by many leading U.S. universities—M.I.T. among them—countless high school graduates, through no fault of their own, are deprived of a chance to study there.

. . . a loss for the students, of course, but also a loss for the colleges, because many of the foreclosed students are "outstanding young people who would do well if they could be admitted," says President Paul E. Gray, '54.

Hence a change in the requirements for admission to M.I.T. beginning in the fall of 1985: if an applicant is lacking the mathematics, physics, or chemistry that is normally required but shows "clear strength in other appropriate areas," he or she may be admitted.

An earlier proposal simply to eliminate high school physics and chemistry as requirements for admission was defeated by the faculty, despite support from the Committee on Educational Policy and President Gray. Gray advocated the change in order to assure "greater diversity of intellectual interest in undergraduates." Another proponent, Peter H. Richardson, '48, director of admissions, told the faculty that he was "convinced that the (chemistry and physics) requirements represent a very severe limit on who applies to M.I.T."—an especially onerous result, he said, at a time when we foresee during the next decade a "significant shrinkage in the population of young people of college age." □

Los Angeles Hospitality

The M.I.T. Club of Southern California invites alumni, faculty, students, families and friends who will be in Los Angeles for the 1984 Olympics (or otherwise) to a pre-opening ceremonies Mixer from 5-9 Friday evening, July 27. The downtown Los Angeles location was being finalized as this went to press. Plans call for an M.I.T. program, generous hor d'oevres, a cash bar, and a modest cover charge.

For further information or directions, call Bill Geist '50, Mixer chairman, at (818) 249-7629.

In addition, should you still require housing for the Olympic period, the club will try to help. Call the Club's housing coordinator, Mardi Margowsky, S.M. '78, at (213) 823-1050. □

CALVIN CAMPBELL

Kevin White (left) honored the M.I.T. Center for Real Estate Development by making his first official public appearance since retiring as mayor of Boston at a Center seminar early this spring. White's thesis: cities need publicly stated land use policies, but they should "make every effort to resist the temptation to adopt strict and rigid policies . . ." that leave city authorities too few options for meeting urban needs. With White in the picture: Professor Gray Hack, Ph.D.'76, head of the Department of Urban Studies and Planning, and Daniel Rose (right), developer of a new high-rise office building in Dewey Square, opposite South Station, in Boston.

How to Save $12 Billion on Defense

Professor William W. Kaufmann—he was budget consultant to four secretaries of defense before Ronald Reagan came into the White House—thinks the 1984-85 defense budget should be cut by $33.7 billion, bringing it to $271.3 billion instead of the $305 billion requested by President Reagan and his Defense Department.

Kaufmann would eliminate a number of the exotic new weapons programs and put some of the savings back into better support for existing systems, with the rest used to reduce the ballooning federal deficit.

In "Setting National Priorites," Brookings' annual budget analysis to be published next month, Kaufmann—he is professor of political science at M.I.T. and a member of the Brookings Institution in Washington—urges cancelling the Air Force MX missile, B-1 bomber, C5B cargo-transport, and Maverick missile; the Army's AH64 attack helicopter and Divan anti-aircraft weapon system; and the Navy's A6E, AV8B, and EA6B aircraft, Phoenix air-to-air missile, CG-47 Aeris cruiser, DDG-51 Aegis destroyers, and as-yet-unnamed new aircraft carriers. In addition, he would curtail research and development on the "star-wars" space defense initiative and reduce procurement of several advanced weapons systems that are already developed.

Kaufmann says major funding for a "star-wars" ballistic missile defense is "ridiculous"; he advocates "a state-of-the-art research and development program just to understand the (technology), so that if the (Soviets) develop something, you can penetrate it." □

Larceny Charges Against Former Student

Two counts of larceny were brought in May by the M.I.T. Campus Police against Kenneth E. Dumas, '83—one for allegedly taking about $30,000 from campus activity accounts to which Dumas had access from 1981 to 1983, and one for allegedly taking $5,300 from the Student Center Committee (SCC) headquarters.

The $30,000 represents receipts from the Student Center 24-hour coffee house, where Dumas worked part-time, and the smaller sum is the proceeds of a concert sponsored by the SCC in April 1983.

Mr. Dumas, an economics major, was president of his class as an undergraduate. But he did not graduate in 1983 and has not reentered the Institute. Classmates and other associates at the Institute were shocked. James Person, '86, chairman of the Student Center Committee, told the *Boston Globe* that Dumas was "very, very well known . . . very active in a number of student activities."

As this issue went to press, Dumas had pleaded guilty and received a suspended sentence upon his pledge of restitution. □

CALVIN CAMPBELL

Astronaut Ronald E. McNair, Ph.D.'76, on a spring visit to his alma mater: "Down in the inner cities . . . are black minds and talent. Great minds and talent with hands with skills to control a spacecraft or scalpel with the same finesse and dexterity with which they control a basketball. This talent must not be wasted."

TARA and Nabisco: Partners for Fusion

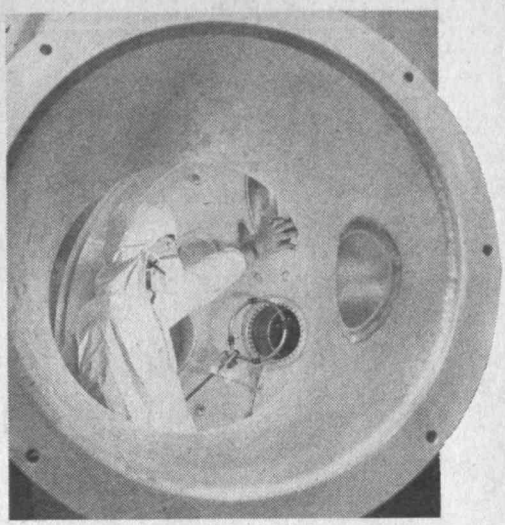
A new 84-foot-long TARA plasma confinement device and the building that houses it were dedicated early this spring by the M.I.T. Plasma Fusion Center.

The building, at 184-190 Albany Street, was once devoted to the distribution of Nabisco food products. It came to M.I.T. as a gift valued at $1.5 million in 1980, when Nabisco moved its New England operations to Rhode Island,. Since then the structure has been extensively rebuilt to become the Nabisco Laboratory.

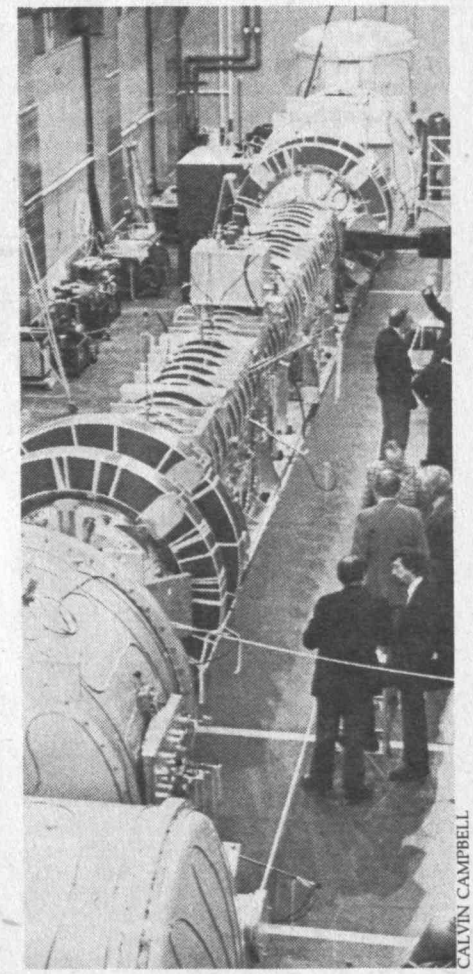
Inside the laboratory is now completed a new tandem mirror experiment designed to hold a plasma of high density and temperature together long enough to sustain the fusion reaction. Although this may be one more step up the ladder to fusion power, TARA's mission is not to create power but to yield an increased understanding of basic tandem mirror physics . . .

. . . tandem mirror because TARA actually has two powerful magnets at each end of its 80-foot-long tube, and the plasma is confined in a long tube with a moderate magnetic field between the two powerful end mangets acting as mirrors.

Renovation of the Nabisco Laboratory and construction of TARA cost $14.9 million, provided to M.I.T. by the Office of Fusion Energy in the U.S. Department of Energy. Completion "heralds a new era in the research capabilities" of the Institute's Plasma Fusion Center, which is one of the principal sources of fusion science and technology research in the U.S. □



This TARA tandem mirror device, completed this spring after three years of work and $14.9 million of U.S. Department of Energy funds, is now being used by the Plasma Fusion Center for studies of basic tandem mirror physics. TARA and the building that houses it—named the Nabisco Laboratory in honor of its donor—were dedicated early this spring. Above: polishing the accelerator; below, a general view of TARA.



CALVIN CAMPBELL

Raymond L. Bisplinghoff came to M.I.T. in 1946 when Professor Jerome C. Hunsaker, '12, then head of the Department of Aeronautical Engineering, offered him a $4,000-a-year assistant professorship. "What do you want me to do?" asked Bisplinghoff. "You can do anything you damn well wish," replied Hunsaker, "but you'd better excel at it." Nearly 40 years later Bisplinghoff, now senior vice-president—R&D at Tyco Laboratories, was back among old friends at M.I.T. to give the 1984 Lester D. Gardner Lecture. His topic was the history of aeroelastic analysis—"a dominant feature of aircraft design" since the beginning of manned flight, he said. In the picture surrounding the lecturer are (left to right) Professors C. Fayette Taylor, '29, Jack L. Kerrebrock, Myron C. Tribus (back to camera), and Edward S. Taylor, '24.

I

Civil Engineering

The M.I.T. Technology Adaptation Program's collaborative work between M.I.T. and Cairo University, Egypt, has been extended for 3.5 years; $10 million will be used for joint activities in science, technology, and development. The work is centered in the Civil Engineering Department at M.I.T., where Professor **Frank Moavenzadeh** is TAP director, and most of the funds will be expended in Egypt by Cairo University's Development Research and Technological Center.

Meanwhile, Professor Moavenzadeh has been honored as the first Leonhard Professor, occupying a chair newly funded by a gift from **William E. Leonhard,** S.M.'40, chairman, president, and chief excecutive officer of the Parsons Corp. Moavenzadeh, at M.I.T. since 1965, is a specialist in transportation, construction, and infrastructure development, and Parsons Corp. is one of the world's largest engineering and construction companies.

John L. Wilson III, Ph.D.'74, has joined the Department of Geoscience at the New Mexico Institute of Mining and Technology, Socorro. A former faculty member at M.I.T., he spent the last 18 months working for Intera Environmental Consultants, Houston, Tex. on the Office of Nuclear Waste's assessment of hydrology at potential waste sites in several western states. . . . **Joseph F. Whittle,** S.M.'74, reports, "I have just been appointed to the position of chief engineer at the Tampa office of Florida Testing Laboratories, a subsidiary of National Foundation Services." . . . **James C. Howland,** S.M.'39, has won the 1983 John Parcel-Leif J. Sverdrup American Society of Civil Engineers Management Award.

Professor **Dick K. Yue,** Sc.D.'80, in the Department of Ocean Engineering at M.I.T. received the 1984 Henry L. Doherty Professorship in Ocean Utilization. Yue's research (during the two-year appointment) will focus on "an improved understanding of second-order loads on a three-dimensional body in waves" . . . to bring an understanding "of second-order wave effects to a level where they can be easily incorporated into engineering design." . . . **Paul F. Rice,** S.M.'47, vice-president of engineering at the Concrete Reinforcing Steel Institute (CRSI), holds the 1984 Arthur J. Boase Award of the Reinforced Concrete Research Council, American Society of Civil Engineers. Rice was cited for his management and direction of research conducted by the CRSI and for his "contributions to the application of research results through national building codes and publications."

Matthew J. Barvenik, Jr., S.M.'77, writes, "Heavily involved with the remediation of hazardous waste sites with emphasis on quality control procedures during construction and post-construction evaluation of slurry cut-off walls. Present work involves piezo cone evaluation of soil/bentonite backfilled cut-off walls." . . . **Jon Hagstrom,** S.M.'65, has been elected vice-president of CBI Industries, Oak Brook, Ill. Prior to this appointment he served as director of research at the firm's research center in Plainfield.

II

Mechanical Engineering

Two members of the department at M.I.T. have received National Science Foundation research grants: Professor **Woodie C. Flowers,** Ph.D.'73, for work on a microcomputer-controlled prosthesis for lower-extremity amputees; and Professor **Neville Hogan,** Ph.D.'77, to study "neurophysiologically-based adaptive controllers" for prosthetic devices.

Three faculty members in the department at M.I.T. are the authors of recently-published books: Professor **Tau-Yi Toong,** Sc.D.'48, *The Dynamics of Chemically Reacting Fluid,* McGraw Hill Book Co., 1983; Professor David Gordon Wilson, *The Design of High-Efficiency Turbomachinery and Gas Turbines,* M.I.T. Press, 1984; and Professor **Nathan H. Cook,** Sc.D. '50, *Mechanics and Materials for Design,* McGraw Hill Book Co., 1984. . . . **Francis J. Zimmermann,** Sc.D.'53, resigned as head of the department of Mechancial Engineering at Lafayette College (in September 1982), but has continued as professor in the department.

David K. Felbeck, Sc.D.'52, reports, "On Octo-

ber 1, 1983, my new book was published (co-author A.G. Atkins), *Strength and Fracture of Engineering Solids* (Prentice Hall, 1984). It is a text for junior-level engineering students with emphasis on the mechanical behavior of engineering materials. I have been professor of mechanical engineering at the University of Michigan since 1961." . . . **William T. Hogan,** Sc.D.'59, president of the University of Lowell (Mass.) since 1981, has been elected chairman of the Northeast Consortium of Colleges and Universities in Massachusetts. . . . **Jack B. Chaddock,** Sc.D.'55, writes that he will serve as general chairman for the International Symposium on Moisture and Humidity in Washington, D.C., on April 14-19, 1985.

The following notices of death have been reported to the Alumni Association: **John A. Oelrich,** S.M.'54, of Avon, Conn., on December 20, 1983; **Yeram S. Touloukian,** S.M.'41, of West Lafayette, Ind., in June 1981; **James S. Hamlin,** S.M.'50, of Cherry Hill, N.J., on April 8, 1981; **Manuel Perez Marcano,** S.M.'51, of Caracas, Venezuela, on May 10, 1977; and **Robert A. Hill,** S.M.'35, of Greenbelt, Md., on January 29, 1984. No further details are available.

III

Materials Science and Engineering

H. Kent Bowen, Ph.D.'71, Ford Professor of Engineering who is associate director of the Materials Processing Center at M.I.T., was the 1984 Sosman Memorial Lecturer at the 86th annual meeting of the American Ceramic Society in Pittsburgh early this spring. His topic: "Chemical Approaches to Ceramic Processing," dealing with chemical methods for preparing ceramic powders and their control during subsequent processing operations. At the same meeting, Professor Bowen and **Paul J. Lemaire,** Ph.D.'80, of Bell Labs received the Society's Ross Coffin Purdy Award for 1984 for an "outstanding contribution to ceramic literature"—their 1982 paper on "Migration of Large Gas-Filled Pores in Potassium Chloride Due to a Temperature Gradient." Two members of the deparment were also honored as new Fellows of the American Ceramic Society at the meeting: **John S. Harrerty,** Sc.D.'65, senior research scientist, and **Harry L. Tuller,** Sc.D.'73, associate professor of ceramics and electronic materials.

John R. Hutchins III, Sc.D.'59, senior vice-president of the Corning Glass Works, Corning, N.Y., has been elected to a one-year term to the board of trustees of Alfred University, N.Y. . . . **Seymour L. Blum,** Sc.D.'54, who has headed his own consulting firm following service as vice-president of ITT Research Institute Corp., has joined Charles River Associates, the economic/consulting firm in Boston, as vice-president. Blum is known in the fields of materials, energy, and environment having been associated with Mitre, Raytheon, and Northern Energy Corp. in the Boston area before moving to Chicago.

Albert W. Schlechten, Sc.D.'40, a member of the Colorado School of Mines faculty for more than 20 years, passed away on February 16, 1984. He had been head of CSM's Department of Metallurgical Engineering from 1963 to 1968 and CSM vice-president for academic affairs from 1968 to 1971, retiring from full-time teaching in 1980. He "instructed, inspired, and infected with enthusiasm, legions of students who have gone on to make substantial contributions to the metallurgical profession . . . his counsel and encouragement helped many young faculty members develop into better teachers because of his guidance," said a board of trustees spokesperson. The winner of several awards, including the Kroll Medal and the George R. Brown Medal, Schlechten also did extensive research, authored several articles, and served as editorial adviser for many technical journals. . . . **James A. Stavrolakis,** Sc.D.'49, of Chicago, Ill., passed away on October 20, 1983; no further details are available.

IV

Architecture

Samuel E. Lunden, '21, who at 86 is still practicing as an architectural consultant, was honored at the end of 1983 at the annual recognition dinner of the Los Angeles Chapter of the American Institute of Architects. In the course of a career that spans almost 70 years, Lunden has designed dozens of Los-Angeles-area buildings, including the Pacific Coast Stock Exchange, the St. Vincent de Paul Church, the Doheny Library of the University of Southern California, and City Hall South. Honors and awards are not unknown to Lunden: he holds the AIA's Edward X. Kemper Award, the Cornerstone Award of the Los Angeles Area Chamber of Commerce, and a number of certificates of merit from the Los Angeles AIA Chapter.

The M.I.T. Professional Practice Program in the Laboratory of Architecture and Planning will hold its annual summer seminar on August 6-10, 1984, and workshop on August 13-17, 1984. "Urban Upgrading—Projects and Policies" will be the subject of the seminar, exploring topical issues through presentations and case study discussions. Projects from Brazil, Egypt, and Sri Lanka will be explored and their implications of theory, policy, and practice for the design professional discussed. The workshop will be a hands-on studio session entitled "Design Evaluation of New Urban Settlements," to which the participants will bring projects for "hands-on" sessions on evaluation tools that allow quantification of designs leading to the improvement of project performance. For further information contact: Professional Practice Program, Laboratory of Architecture and Planning, M.I.T., Room 4-209, Cambridge, MA 02139, (617) 253-1350.

Reinhard Goethert, M.Arch.'70, research associate at M.I.T., was the principal guest lecturer at a recent seminar on "The Design and Planning of Housing" at the University of Petroleum and Minerals, Dhahran, Saudi Arabia. Goethert presented the keynote address and five other papers during the six-day session, ranging from design principles, survey techniques, to case examples. Participants, drawn from the various ministries throughout the country, included architects, planners, and engineers.

Jesus M. Bondoc, M.Arch.'50, dean of the Institute of Architecture and Fine Arts at Far Eastern University, St Metro Manila, Philippines, passed away on February 29, 1980; no further details are available.

V

Chemistry

Frank Arlinghaus, Ph.D.'66, senior research scientist at General Motors Corp., has been named a lecturer in the School of Arts and Science at Lawrence Institute of Technology, Southfield, Mich. . . . **Robert F. Goddu,** Ph.D.'51, director of administration for research and development at Hercules, Inc., Wilmington, Del., took early retirement on March 1, 1984, after more than 32 years of service. He was research manager for fibers and film from 1967 to 1977, then became manager of materials science and central research until 1980. Goddu and his wife Betty will continue to live in Kennett Square, Penn.

VI

Electrical Engineering and Computer Science

President **Paul E. Gray,** '54, has been elected a councilor of the National Academy of Engineering for a three-year term, and **Mildred S. Dresselhaus,** Abby Rockefeller Mauze Professor in the department, has been re-elected to a similar term as councilor.

The TX-0 computer, a major achievement in 1956 at Lincoln Laboratory when it was the first transistor-based computer, is up and running for the third time—this time at Boston's burgeoning Computer Museum. After two years at Lincoln, the TX-0 was dismantled and reassembled at M.I.T., where it operated until the mid-1960s. **John McKenzie,** who was responsible for the TX-0 at M.I.T., was the Computer Museum's operations manager for the project, and he joined a score of more TX-0 "alumni" for a special celebration at the museum late last year. Among those present: Professors **Jack B. Dennis,** '53, **Donald E. Troxel,** Ph.D.'60, and **Jonathan Allen,** Ph.D.'68; **John E. Ward,** '43, of the M.I.T. Laboratory for Information and Decision Systems; **Douglas T. Ross,** S.M.'54, chairman of Softech, Inc., **Alan Kotok,** '62, **Harrison R. ("Dit") Morse, III,** '59, **David A. Gross,** '61.

Nathaniel I. Durlach, senior research scientist in the department, is the recipient of a National Sci-

How to Unleash Technology

Eight problems constrain technology from having its broadest possible impact on the U.S. economy, says Gerald D. Laubach, Ph.D.'50, chairman of Pfizer, Inc., and of the Innovation, Technology, and Science Policy Committee of the National Association of Manufacturers:

☐ Shortages of technical manpower, caused in part by faculty shortages and obsolete equipment in educational institutions and poor precollege courses in mathematics and science.

☐ Inefficiencies in the patent system, including delays that result in loss of patent life.

☐ Inadequate protection for proprietary data. Indeed, charges Laubach in the NAM's journal *Enterprise*, "many requests for disclosure under the Freedom of Information Act are commercially motivated."

☐ Regulatory impediments that force industry to divert resources from more productive investments.

☐ Export controls that limit the market for American products or make them uncompetitive.

☐ Antitrust constraints on cooperative research, a factor sharpened by the treble damages facing companies found in violation.

☐ Government's failure to grant tax relief on research and development investments.

☐ Problems "that limit academia's ability to cooperate with industry and maintain continuity of research."

Though Lauback admits his NAM committee won't tackle all of these frustrations in 1984, he pledges special help on those relevant to the President's Commission on Industrial Competitiveness, of which he is a member. "We'll come up with solid recommendations," he promises.

The New Inflationary Universe: Expanding On the Big Bang

Did the universe really evolve out of next to nothing? Alan Guth, Associate Professor of Physics, thinks so.

Back in December 1979, Guth arrived at what he calls "a spectacular realization"—a set of equations that solved some major problems with the then-current theoretical version of the big bang, the explosion that started up the cosmos. Since then, Guth and other astrophysicists have refined the concept of the inflationary universe, as he dubbed it. At the spring meeting of the American Physical Society in Washington, Guth summarized recent efforts to reconcile the theory with observed reality.

The key to the concept is Guth's suggestion that the universe went through a brief period of extraordinarily rapid inflation during its first 10^{-30} second of existence. The expansion increased its diameter by a factor perhaps 10^{50} times more than previously thought possible. It also seemed to account for three major concerns of big bang theory: the amazing uniformity of the cosmos, as measured by astronomers; the remarkable closeness of the measured density of the universe to the critical figure that marks the difference between an ever-expanding cosmos and one that will eventually contract; and the absence, at least in searches so far, of the fundamental magnetic particles known as monopoles that, according to big bang cosmology, should have formed in abundance in the early universe.

However, the original idea of inflation, which stemmed from the so-called grand unification theories developed to explain the behavior of elementary particles and the forces that link them, created a conundrum of its own: "There was no graceful way to end the period of exponential expansion," admitted Guth.

Enter the *new* inflationary universe. Developed by A. Linde of Moscow's Lebedev Physical Institute and independently by Andreas Albrecht and Paul J. Steinhardt of the University of Pennsylvania, this approach focuses on special versions of grand unified theories that predict a gradual congealing of the rapidly inflating cosmos.

ence Foundation grant for studies of the tactile communication of speech.

William M. Siebert, '46, who has been a member of the M.I.T. faculty since completing his doctorate in 1952, has been named Ford Professor of Engineering. The honor recognizes Professor Siebert's contributions as a communication system theorist and as an engineering educator. His current research is on the management of acoustic information in the human auditory system.

Lofti A. Zadeh, S.M.'46, professor of electrical engineering and computer science at the University of California, Berkeley, has been appointed to the newly-established Technology Advisory Board for the United States Postal Service and to the Advisory Committee for the Directorate of Biological, Behavioral, and Social Sciences at the National Science Foundation. . . . **Ernest J. Angelo,** Sc.D.'58, retired from Bell Laboratories in December 1982. . . . **Robert J. Shillman,** Ph.D.'74, is president of Cognex Corp., Needham, Mass., a leader in the field of computerized vision equipment. Shillman was recently successful in raising $2.5 million in venture capital to expand manufacturing and marketing of Cognex's products. . . . **Abhay Bhushan,** S.M.'71, has received the Community Service Award from the Association of Indians in America—Genesee Valley (N.Y.) Chapter. . . . **Arthur J. Schneider,** Ph.D.'59, former vice-president of advanced technology, computer systems unit, at Sperry Corp., New York City, has become vice-president and general manager of the Sperry Research Center. . . . **H. Newton Garber,** Sc.D.'56, is president of The Institute of Management Sciences (TIMS).

Steven H. Valdman, S.M.'81, reports, "I am presently working in Burlington, Vt., for IBM. My work consists of computer modelling of reliability concerns in static bipolar RAMs. I am teaching (at IBM) an in-house course in bipolar device physics and taking additional courses in physics at the University of Vermont." . . . **J. David R. Kramer, Jr.,** Sc.D.'64, has been named the first consulting scientist under a new Mitre Corp. program to utilize staff members' scientific and technological know-how throughout the company. Kramer will function on a broad scale and work independently within general areas of upper management as a consulting engineer.

Gerhard L. Hollander, '53, president and technical director of Hollander Associates, Fullerton, Calif., has been awarded a Centennial Medal of the Institute of Electrical and Electronics Engineers. Hollander was cited as a pioneer in the development of today's computer systems who has led research efforts on methods for the design and planning of some of the nation's largest information systems. . . . **Kenneth E. McVicar,** S.M.'50, vice-president for plans and programs at the Mitre Corp., Bedford, Mass., retired on April 1, 1984, to devote his full-time to his real estate business. McVicar has been affiliated with Mitre since its formation in 1958.

Edward A. Palo, S.M.'65, associate department head of the Signal Processing Electronic Warfare Department at The Mitre Corp., Bedford, Mass., has been promoted to head of the department. Palo has specialized in state-of-the-art advances in high-resolution radar, signal intercept and analysis, antijam communications and data links, and error-correction codes. . . . **Charles A. Freeman,** S.M.'81, reports, "I have been working at Hewlett-Packard Laboratories, Palo Alto, Calif., for over a year now, doing research in the area of computer networks. I have been involved in many outdoor and community activities as well and have joined a volunteer mountain search and rescue team, taken a course to become an emergency medical technician, and taught first aid and CPR for the Red Cross. Also I have been on three searches in the Sierra Nevada and spent two weeks ski mountaineering in Alaska."

Two deaths have been reported to the Alumni Association, with no further information available: **Chandra S. Ghosh,** S.M.'46, of Calcutta, India, in December 1968 and **Everett W. Harris** of Reno, Nev., on September 7, 1983.

VI-A Program

Besides a record 228 applicants this spring the VI-A cooperating companies came up with an unprecedented 146 openings for new students. Unfortunately, the department's allowable quota for the new VI-A class, after taking into account expected continuing participants, was only 95. This meant, for the first time, that some drastic cuts had to be made from the desires of some companies.

Ultimately, 112 openings were entered into the matching process and the computer was able to come up with 104 initial matches. Conferences were had with all of these matched students, and subsequently, with others whose names came up when several of the matched students decided not to accept, and at this late April writing, it looks as if the new VI-A class will level off at 103 students (25 percent of the EECS sophomore class). Last year's entering class numbered 109, by comparison, matched to 123 openings.

An accolade for VI-A alumnus **Andrew J. Viterbi,** '56. Dr. Viterbi has been selected by the IEEE to receive the 1984 Alexander Graham Bell Medal "for fundamental contributions to telecommunications theory and practice and for leadership in teaching." He will receive the award in Boston on May 13, during Electro/84 which celebrates the centennial year of the IEEE (and the AIEE, the parent society from which it grew). Dr. Viterbi is cofounder, along with Dr. **Irwin M. Jacobs,** '57, of M/A Linkabit, Inc., San Diego, Calif., and currently is their president.

Also receiving a high honor is one of our VI-A faculty advisors, Professor **William M. Siebert,** '46, who has been named Ford Professor of Engineering in the EECS Department. This chair is one of seven endowed by the Ford Foundation in M.I.T.'s School of Engineering. Professor Siebert serves as VI-A faculty advisor to Hewlett-Packard Co.'s Medical Group in Andover and Waltham, Mass. The most recent previous occupant of this chair was Professor **Robert M. Fano,** '41, also a VI-A faculty advisor acting as liaison with the Digital Equipment Corp. Professor Fano retires this June after over 40 years at the Institute.

VI-A alumni signing our guest book since our last writing included: **John Dana Chisholm,** '75, now a consultant in San José, Calif., who was east on business; and **Steven K. Ladd,** '81, who's with Megatest Corp. in Santa Clara, Calif., who stopped in to see Director Tucker.—John A. Tucker, Director, VI-A Program, M.I.T., Room 38-473, Cambridge, MA 02139

T. Marshall Hahn, Jr.

VIII

Physics

Professor **Kerson Huang** has fulfilled a lifelong dream by completing a new translation of the *I-Ching*, the ancient Chinese book used for devination and prophecy. The result is now available on a

floppy disc for the IBM PC and Apple II, and it will soon be published in book form by a Singapore-based publisher. Many find the accuracy of the *I-Ching* to be "uncanny," says Huang. He thinks that's so because the *I-Ching* tends "to suggest to us things that are already in our minds"→a view that is consistent with psychologist Carl Jung's interest in the *I-Ching* as a valuable tool for achieving insight into the mind. Pending publication of the book, the floppy disc *I-Ching* is available from Huang for $69.95 at Box 1083, Marblehead, MA 01945.

Professor **Edward H. Farhi** of M.I.T. has been honored by the Alfred P. Sloan Foundation as a Sloan Research Fellow and will receive a $25,000 grant to support his research activities. . . . Professor **Walter H.G. Lewin** in the department at M.I.T. is co-author of *Accretion Driven Stellar X-Ray Sources* (Cambridge University Press, 1983). . . . **T. Marshall Hahn,** Ph.D.'50, president and chief executive officer of the Georgia-Pacific Corp., Atlanta, Ga., has been named, in addition, chairman of the board. Hahn was elected president in 1976 and chief executive officer in 1983. . . . **George D. Prestwich,** S.M.'52, formerly president of RCA Service Co., has become staff vice-president of planning and development of the RCA Corp., New York City. . . . **Robert Dudley,** Ph.D.'51, head of the Section of Medical Applications, Division of Life Sciences, at the International Atomic Energy Agency, Vienna, Austria, has been promoted to the rank of principal officer.

IX

Psychology

Professor **Gerald E. Schneider,** Ph.D.'66, has added an affiliation with the Whitaker College of Health Sciences, Technology, and Management to his duties as professor of psychology at M.I.T. An authority on the relationships between brain structure and behavior, Dr. Schneider will work in Whitaker's new brain science program.

X

Chemical Engineering

M.I.T. and its alumni had prominent parts in the 75th anniversary celebration of AIChE in Washington late last year. Of 30 AIChE members honored as "eminent chemical engineers," nine are members of the Institute community:

□ **Manson Benedict,** Ph.D.'35, professor emeritus of nuclear engineering—"one of America's most renowned nuclear engineers."

□ **W. Kenneth Davis,** '40, of Bechtel Corp.—". . . a long and distinguished career in academia, government, and industry."

□ **Thomas B. Drew,** '23, professor emeritus of chemical engineering—". . . a long and distinguished career in chemical engineering, especially in the field of heat transfer."

□ **Hoyt C. Hottel,** '24, professor emeritus of chemical engineering—"the world's foremost expert on combustion heat transfer."

□ **Arthur E. Humphrey,** S.M.'60, provost and academic vice-president of Lehigh University—". . . a long and distinguished career in the field of biochemical engineering and biotechnology."

□ **Ralph Landau,** Sc.D.'41, chairman of the board of Listowel, Inc.—". . . major contributions to organic chemical technology."

□ **Jerry McAfee,** Sc.D.'40, chairman and chief executive officer of Gulf Oil Corp.—". . . a distinguished industrial career."

□ **Arthur B. Metzer,** Sc.D.'51, professor of chemical engineering at the University of Delaware—". . . a leader in research on fluid mechanics."

□ **James Wei,** Sc.D.'55, head of the Department of Chemical Engineering at M.I.T.—"an expert in catalysis, reaction engineering, and air pollution control."

At the same meeting, two members of the M.I.T. faculty received major awards:

□ **Charles L. Cooney,** Ph.D.'70, the Food, Pharmaceutical and Bioengineering Division Award.

□ **Edward W. Merrill,** Sc.D.'47, the Alpha Chi Sigma Award for research in biomedical engineering and polymers.

And AIChE Founder's Awards were given to three M.I.T. alumni: **W. Kenneth Davis,** '40, **Margaret Hutchinson Rousseau,** Sc.D.'37, and **Robert B. MacMullin,** '19. Ms. Rousseau was cited as the first woman member of AIChE and the first to be awarded a doctorate in the field from M.I.T.

Albert S. Humphrey, S.M.'49, writes from London that 1983 was a professional "break-through" year for his firm, Business Planning and Development. The company expanded into Benelux, acquiring an office building in Antwerp that will be occupied by February 1984, and conducted a number of successful training programs for both old and new clients. Mr. Humphrey himself was named a visiting lecturer at the Newcastle Polytechnique Business School.

Ralph Landau, Sc.D.'41, who is consulting professor in economics and chemical engineering at Stanford as well as chairman of Listowel, Inc., of New York, has been re-elected vice-president of the National Academy of Engineering for a four-year term.

David S. Hacker, S.M.'50, of the Department of Energy Engineering, University of Illinois, Chicago, reports that he is involved in exploratory process development and research, responsible for new process evaluation, as well as research into new separation technology. His daughter Karen Anne is a second-year resident in internal medicine at Boston City Hosptial, planning to specialize in adolescent medicine; and his daughter June Ruth is completing graduate work in architecture at the University of Illinois. . . . **Ronald E. Rosensweig,** Sc.D.'59, has completed 15 years of continuous service on the board of the Ferrofluidics Corp., a Massachusetts corporation of which he is co-founder.

Sudhakar Kesavan, '84, is presently working as an associate with ICF, Inc., a Washington, D.C.-based policy consulting firm, with major assignments in the area of effects of regulation on the chemical industry. . . . **Robert J. Richardson,** Sc.D.'54, formerly executive vice-president and a member of the Executive Committee and director of E.I. du Pont de Nemours and Co., became president (on May 8, 1984) of Bell Canada Enterprises, Inc., Montreal, Canada.

Robert Leroy Jacks, S.M.'46, was killed in an automobile accident in Quechee Village, Vt., on December 31, 1983. For the past 11 years Jacks had been with the Union Carbide Corp., for the past 7 years as director of administration and planning of the Health, Safety, and Environmental Affairs Department of Union Carbide. Jacks was an active member and fellow of the American Institute of Chemical Engineers, serving as president of the Management Division and president of the New York section. Before joining Union Carbide, Jacks had been a staff member of the Exxon Corp. and the M.W. Kellogg Corp., New York City, and owner of an engineering and environmental management firm. . . . **Benjamin F. Juscen,** '54, a senior staff engineer in the space system division of Lockheed Missile and Space Co., passed away on January 28, 1984. Prior to joining Lockheed, he worked for B.F. Goodrich, General Dynamics, and Technical Plastics in plastics manufacturing and research. . . . **Rafael Valdez,** S.M.'33, of Milagro, Ecuador, passed away on January 18, 1978.

Emmett T. Craig, S.M.'47, a retired employee of Exxon Co. U.S.A. with 36 years of service and an Army captain in the bomb disposal unit during World War II, passed away in Baton Rouge, La., on January 7, 1984. . . . **Robert L. Jacks,** S.M.'46, manager/administration of health and safety at the Union Carbide Corp., Danbury, Conn., was killed in an automobile accident in Vermont on December 31, 1983. He was a fellow and a former director of the American Institute of Chemical Engineers. . . . **Charles L. Davis, Jr.,** '32, a director at Interstate Paper Corp., Riceboro, Ga., passed away on May 4, 1979, in Flagler Beach, Fla. . . . **Alexander C. Burr,** '32, of Bismarck, N.C., passed away on August 30, 1977. He is surved by his wife, Lillie, a son, a daughter, and six grandchildren. . . . **Louis L. Colin,** S.M.'32, of Harare, Zimbabwe, passed away in September 1983; no details are available. . . . **Arnett E. Bention,** '37, of San Marcos, Calif., passed away in May 1982; no details are available.

XI

Urban Studies and Planning

The late Professor **Kevin Lynch** and Associate Professor **Gary Hack** have recently completed the third edition of *Site Planning*, published by the M.I.T. Press, 1984.

Michael L. Seltz, M.C.P.'67, former associate partner in the Washington office of Skidmore, Ownings & Merrill, is a founder of Oldham & Seltz, Washington, D.C., an architectural and interior design firm.

Arthur W. Busch, S.M.'52, was visiting professor in the graduate program in environmental sciences at the University of Texas, Dallas (1982-82) and was appointed to the Environmental Health Commission for the city of Dallas in 1983.

Heinz D. Besser, Ph.D.'80, of Rio de Janeiro, Brazil, passed away on November 11, 1981; no further details are available.

XII

Earth, Atmospheric, and Planetary Sciences

Stewart Nozette, Ph.D.'83, is leader of a summer study at the California Space Institute (University of California at San Diego) on the nature and impact of a shift during the next 25 years from earth-based to space-based resources derivation and operations. An interdisciplinary team of faculty from 20 colleges and universities is conduting the study, supported by a workshop series given by industry, university, and government experts. The program is sponsored by NASA under the auspices of the American Society for Engineering Education.

Richard Lindzen, who came to M.I.T. from Harvard last summer, is now Alfred P. Sloan Professor in Meteorology. His specialty is atmospheric fluid dynamics, and he is among those credited with our understanding of chemical and thermal drives for winds in the region where ozone is an important atmospheric constituent.

XIII

Ocean Engineering

Roderick M. White, Sc.D.'65, dean of academics at the Coast Guard Academy, became executive director of the Coast Guard Academy Foundation, Stonington, Conn., upon his retirement in November 1983. The foundation is a private organization that raises money for cadet programs and capital improvements at the academy. . . . **Robert M. Walters,** S.M.'71, retired from the U.S. Navy in 1980 and has been general manager of the Washington office of the American Systems Engineering Corp. since September 1981, active in the development and implementation of phased maintenance programs of U.S. Navy auxiliary, amphibious, and combat ships. Walters writes, "Miss M.I.T., Boston, and New England!" . . . **Edward McCann,** S.M.'70, has recently been appointed to the position of director—planning, at Sperry Electronic Systems, Great Neck, N.Y. . . . **Bruce C. Skinner,** S.M.'65, has been appointed to head of the Department of Engineering at the U.S. Coast Guard Academy, New London, Conn. . . . **David S. Greeley,** Ph.D.'82, writes, "Starting new company, Atlantic Applied Research Corp., with **Neal A. Brown,** Ph.D.'64, and four others. Consulting in hydrodynamics, naval acoustics, sonar, and related fields."

Productivity vs. Inflation

The rate of inflation in the U.S. may increase slightly in 1984 and 1985, to perhaps 6 percent a year. But if all goes well this need not be the beginning of another rise toward the double-digit inflation of the past decade, says Stephen K. McNees, Ph.D.'70, vice-president of the Federal Reserve Bank of Boston.

The critical factor in 1986 and 1987 will be productivity: Can it be increased fast enough to hold down prices despite continued economic expansion?

McNees' analysis, published early this year in the *New England Economic Review*, is based on a study of trends in unemployment, compensation, and productivity. He concludes that two factors were critical in causing the inflation of the 1970s: decreased productivity and "price shocks" in energy and food. The latter are especially a threat for the future, says McNees: our vulnerability to shortfalls of critical goods such as energy and food will be greater as economic growth brings our consumption of these goods ever closer to our capacity to produce them.

James Staub, S.M.'71, reports that he received the Navy Meritorous Service Award for duty as ship management officer of the *USS New Jersey* (BB62)—reactivation and modernization—October 1, 1981 to December 15, 1982. . . . **Thomas Hennessey,** S.M.'46, is currently a sales associate for Jack Conway, Realtor, Co., West Roxbury, Mass. . . . **John C. Scalzo,** S.M.'73, is a commander in the U.S. Navy and ship engineering officer at Commander, Naval Air Forces, Atlantic Fleet, Norfolk, Va. . . . **Roderick M. White,** Sc.D.'56, dean of academics at the Coast Guard Academy, delivered Mitchell College's (New London, Conn.) 39th annual commencement address last May 1983.

Frank L. Bowman, S.M.'73, has assumed command of the submarine *City of Corpus Christi*, Groton, Conn. . . . **Louis H. Roddis, Jr.,** S.M.'44, a consulting engineer in Charleston, S.C., is now a member of the board of directors of Detroit Edison Co. He is chairman of the Energy Research Advisory Board of the U.S. Department of Energy and is a consultant to several governmental agencies and private companies in the energy, utility and marine fields.

Rear Admiral **Lloyd Harrison,** U.S.N.(Ret.), S.M.'22, passed away on May 5, 1983. His last Navy assignment prior to retirement in 1955 was as assistant chief of the Bureau of Aeronautics; he was manager of the Naval Aircraft Factory in Philadelphia during World War II. Following Navy retirement, Admiral Harrison joined McDonnell Aircraft Corp. as vice-president in charge of procurement, and after his "second" retirement in 1962 was for two years was the receiver of the Howard Foundry in Evanston, Ill.

Walter M. Vincent, S.M.'48, a member of the quality control department at the Charlestown Navy Yard since his retirement in 1970, passed away in Weymouth, Mass., on October 28, 1983. Vincent was a navy veteran of World War II, retiring as full commander after 20 years of naval service. . . . **Halil E. Dagdevirenoglu,** S.M.'44, of Istanbul, Turkey, passed away after a long illness on April 15, 1983. Dagdevirenoglu retired from the Turkish Navy as captain in 1960 and became the business manager of Robert College of Istanbul, a secondary school in Turkey sponsored by U.S. philanthropic institutions. "During his lifetime, he was always very appreciative of the excellent education he had received at M.I.T. as a young Turkish naval officer," writes his wife Keriman. . . . **Daniel Lynn Carroll, Jr.,** a captain in the U.S. Navy from La Jolla, Calif., passed away on June 26, 1981; no further details are available.

XIV

Economics

Stephen DeCanro, '72, is professor of economics at the University of California, Santa Barbara, and vice-president of the Economics Group, Inc. (Santa Barbara), an economics consulting company. . . . **Edward Moscovitch,** Ph.D.'66, vice-president of Data Resources, Inc., Lexington, Mass., is also an accomplished artist. Over 20 of his paintings (watercolors) were exhibited in his first one-man show last February at the Wenham (Mass.) Public Library. Moscovitch's works are inspired by the New England scene—barns, houses, boats, meadows, marshes, and harbors.

XV

Management

Martin Greenberger, professor of public policy and analysis at UCLA who taught in the Sloan School for more than a decade beginning in 1958, is the author of *Caught Unawares: The Energy Decade in Retrospect* (Ballinger, 1984). The book, written in collaboration with Professor Gary D. Brewer of Yale, Professor William W. Hogan of Harvard, and Milton Russell of Resources for the Future, is described as a study of how policy analysis was applied to the energy problem—and how it can be a more useful tool for analyzing democracies' problems in the future.

Though personal computers are proliferating rapidly and influencing all facets of life, concepts and terminology are too little understood by the public, even by many computer users. To help users understand their machines, **Hoo-min D. Toong,** '67, lecturer in the Sloan School, and **Amar Gupta,** postdoctoral fellow, have collected a series of recent articles into *Personal Comuters: A Primer of PC Technology* (South Bend, Ind.: And Books, 1983.)

Shlomo Maital, visiting professor in the Sloan School on leave from Technion-Israel Institute of Technology, is co-author with his wife, Sharone L., of *Economic Games People Play* (Basic Books, April 1984). The Maitals use of insights of psychology and economics to illuminate the "complex, ongoing economic games in which we use our skill, experience, and contributions to attain happiness and security for ourselves and those we love by securing shares of wealth and resources."

A fourth new book in this month's report: *The Mediators* by **Deborah M. Kolb,** Ph.D.'81 (M.I.T. Press, 1984), a summary of how labor mediators in the Federal Mediation and Conciliation Service and similar state agencies work to resolve disputes between management and labor. The mediator is "a social actor who creatively carves out a strategic situation where he has little authority or control," according to Kolb's hypothesis. She finds that all mediators achieve their place by adopting "a fairly consistent style based on experience"—but not by invoking any standard formula or rule. Kolb is associate professor of management at Simmons College.

Paul N. Schregel, S.M.'64, is currently director of marketing research and corporate vice-president of the packaged products division of the Scott Paper Co., Philadelphia, Penn. . . . **Harvey C. Berger,** S.M.'76, writes that he is an attorney at McInnis, Fitzgerald, Ross, Sharkey, and McIntyre and is enjoying the sun and weather in wonderful San Diego. . . . **Melford E. Monsees,** '58, is coordinator of the University of Missouri Graduate Engineering Program, Kansas City, and an associate of Richard Muther and Associates, Inc. He's an active member of the M.I.T. Educational Council in the Kansas City area. . . . **Julius J. Bellaschi,** S.M.'58, has been director of programming analysis and evaluation for the Department of the Army since July 1982. . . . **Stanley C. Abraham,** S.M.'69, writes, "Have been associate professor of strategic management at Pepperdine University School of Business and Management, Los Angeles, Calif., since 1981. Also president of my own consulting firm, Future By Design, Santa Monica."

Barclay B. Rockwood, S.M.'81, is currently director of production planning for Congoleum Corp., Kearny, N.J. . . . **Debra A. Tessier,** S.M.'83, writes, "First in my class to switch jobs. I have left American Express and joined E.F. Hutton as a department manager in M/S Services." . . . **Geoffrey Stiff,** S.M.'80, writes, "Recently accepted a new position at General Electric corporate headquarters as a consultant for financial planning, primarily working on acquisition and disposition reviews. Became a father again on January 10, to a 8-pound, 5-ounce baby boy." . . . **Robert Cayleff Weiss,** S.M.'74, was promoted to manager of corporate planning at Amerada Hess Corp. in October 1983. . . . **Vinod K. Dar,** S.M.'75, vice-president of Hagler, Bailly and Co., has been named a director of Hadson Petroleum Corp., Oklahoma City, Ok.

Walter N. Vaughan, S.M.'61, of Guelph, Ontario, Canada, passed away on December 16, 1983. Vaughan, was secretary of the University Senate (since 1979) and part-time teacher in the School of Engineering at the University of Guelph. Prior to his university association, he had worked a number of years in industry as an engineer, computer programmer and analyst, joining the University's Registrar's Office in 1965. A note for the memorial service described Vaughn as "much more than merely a professional engineer. In spite of his heavy university responsibilities, he maintained an active interest in many facets of community life . . . his humor and genuine human nature were always evident."

David Walter Rumsey, S.M.'62, of Paris, France, passed away in October 1983; no further details are available.

Sloan Fellows

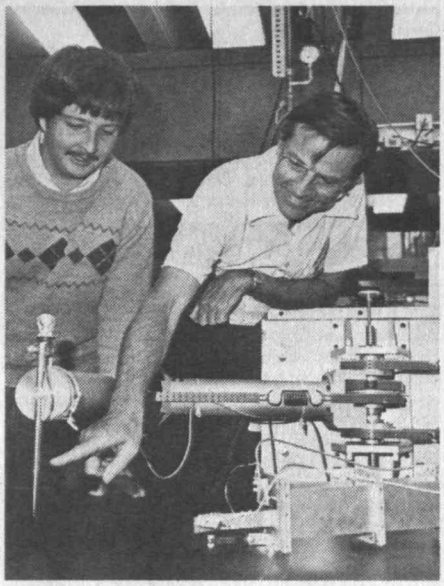
Patrick E. Coggins, S.M.'74, is vice-president of Sun Co., Inc., Radnor, Penn. Previously, Coggins was vice-president of Sun Refining and Marketing Co., a subsidiary. . . . **Henry C. Hale,** S.M.'79, has been appointed production manager of the General Motors Assembly Division, Framingham, Mass. Hale, with General Motors since 1968, has served as general superintendent of production at GM's Willow Run plant, Ypsilanti, Mich. . . . **Robert S. Ames,** S.M.'54, retired executive vice-president (aerospace) at Textron, Inc., has become director of the Pneumo Corp., Boston, and of the Esterline Corp., Darien, Conn.

Laurence S. Liebson, S.M.'79, writes, "I have recently co-founded (1982)—and serve as president of—another high-technology start-up company: Xyvision, Inc., located on Route 128 (Woburn, Mass.), manufacturers of advanced work stations and integrated computer systems for electronic publishing applications."

Senior Executives

Harvey L. Pastan, '81, manager of the Electronics Systems Section since 1979 at Arthur D. Little, Inc., Cambridge, has been elected a vice-president of the firm. . . **William C. Weitzel, Jr.,** '74, has been promoted from vice-president to senior vice-president at Texaco, Inc., White Plains, N.Y. . . . **Raymond F. Pettit,** '70, former senior vice-president and chief financial officer of Colgate-Palmolive Co., has become senior vice-president and chief financial officer of Rockefeller Center, Inc., New York City. . . .

Professor Robert Cannon, Sc.D.'50, head of the Department of Aeronautics and Astronautics at Stanford, consults with graduate student Michael Hollars on a subset of the problem of making a robot arm that operates like a human arm—"deft, light, and flexible."



CHUCK PAINTER

Cannon's Quest for Excellence at Stanford

"Picking the Right People Is the Whole Show," He Says

by Donald Stokes

In their effort to maintain at Stanford University a top-notch center for training aerospace engineers, Professor Robert Cannon, Sc.D.'50, and his colleagues are working on such far-ranging questions as how to prove Einstein's monumental General Theory of Relativity and how to spawn a new era in "intelligent" robots.

Cannon thinks this kind of diversity is one key to building a successful university department. But an even more important one, he believes, is to choose with painstaking care exactly the right sort of faculty. "Picking the right people is the whole show." Cannon is well-known for having done that earlier at Caltech, where he headed the Engineering Division from 1974 to 1980. This is Cannon's second period at Stanford. From 1959-70 he served as vice-chairman of his present department and also founded and directed the Guidance and Control Laboratory. In between, he was chief scientist of the U.S. Air Force (1966-68) and later U.S. Assistant Secretry of Transportation (1970-74).

Must Robots Be Clumsy?

His department's emphasis on robots arises because Cannon does not think the present generation of robots comes close to their real potential. "The robots you see today . . . in factories or in space . . . are not very bright, and they are also awfully clumsy."

He imitiated the jerky movements of the typical robot: "Factory robots are klutzes—big heavy things. A robot built to pick up a light object is apt to be a five-ton monster, and you'll be lucky if it even has touch sensors so it doesn't smash the thing it's meant to pick up.

"What our team is interested in is robots that are deft, that are light and flexible and don't use much energy." Again he imitated a robot, but this time in a gently-sweeping decisive movement.

"See? The key to it is to be able to sense where your fingers are. I can look at my hand and control what I am doing. A robot cannot do that, at present. It has to make a series of mechanical pre-set jerks." But that may not be true for much longer, says Cannon, pointing to a group of researchers working on a robot with a number of interconnected drives and sensors. "This robot arm is a beam which is extremely flexible, but its tip can be controlled to a gnat's eyebrow," he said. "We can see where the tip is and we know how to use that information to control the muscles instantaneously. And nobody else has been able to do that."

Other teams in Cannon's department are working on other components, but Cannon says that it will be some time before a complete robot is assembled to operate as the team plans: "It may be two robot generations hence before the full scope of our ideas becomes a reality. We are working on principles that are completely new. . . . We are all trying to mimic nature, and nature is a lot smarter than we are. We have to take baby steps, a little at a time, but we are getting there."

Testing Einstein's Theory

Meanwhile, a definitive attempt to test Einstein's General Theory of Relativity, which postulates that space, time, and gravity interlock in the master pattern of the universe, has been going on in Cannon's department at Stanford for 20 years. Another seven years may be needed before the apparatus being painstakingly assembled is lofted into the cosmos aboard a space shuttle. The scheme is to use an extremely accurate gyro, about two million times more accurate than the state of art, to test for the first time a fundamental part of Einstein's General Theory having to do with miniscule gravitational forces.

The accuracy demanded by the experiment is unprecedented. The gyroscope must be able to detect an angular variation as small as the angle subtended by a human hair ten miles away, and to do that it must operate at cryogenic temperature and zero gravity.

The basic components of the apparatus have been developed; indeed, every piece has been proven in the laboratory. The next step is to fit the pieces into a single system for operation in a dedicated satellite, to be launched from the space shuttle.

Professor Cannon is a prominent example of the idea current at Stanford—and also at M.I.T.—that the top faculty are best qualified not only for research but also to teach undergraduates. Currently, he is teaching one undergraduate and two graduate courses. He is also chairman at Stanford's Budget Advisory Committee, where one of the major problems is dealing with indirect costs, just as it is at M.I.T. □

DONALD STOKES is a staff writer for the Stanford University News Service.

Designing a robot arm that is extremely flexible but can be controlled "to a gnat's eyebrow."

Heinz K. Hofmeister, '74, former director of corporate planning at Hoechst AG, West Germany, has become group vice-president of American Hoechst Corp., a subsidiary.

John W. Darrin, '63, technical director at American Shoe Machinery Co., Woburn, Mass., passed away on February 3, 1984. . . . **German A. Yia,** '57, formerly vice-president and director of Altantic Gulf and Pacific Co., Manila, Philippines, passed away on December 28, 1971. . . . **Lester G. Crunkleton,** '63, of Tarpon Springs, Fla., passed away on January 21, 1984; no further details are available.

Management of Technology Program

Elliot S. Blackman, S.M.'82, was on campus in March recruiting in the Engineering School for Digital Equipment Corp. (He took a position with their Hudson, Mass., division late last year.) While here, Elliot met with several of the current Management of Technology Program students over lunch and had a chance to talk to them about his efforts at DEC. . . . **Richard H. Bullen,** S.M.'82, gave Jane Morse a call in March to "catch up." He finds "making a new business work and survive" (Bullen Management Co., New York) still very exciting indeed, and enjoys the task of computerizing their operations as well. Chris is due with their second child in May. Valerie, who's now four-and-one-half, will be going to kindergarten and has decided that living in Hastings-on-Hudson isn't so bad after all!

Kenneth W. Miller, S.M.'82, was at M.I.T. in March recruiting for Duracell. He stopped off to have lunch with Jane Morse and a few of the Management of Technology students and talked with them about Duracell's changing organizational structure and his function as product engineering manager. His son, Kenny (now 2?), has become a favorite traveling companion for his dad, and Ken often takes him along on trips to Boston, Atlanta, and New York. Joan is in an executive MBA program at Wake Forest and was due with their second child in April. . . . **Henry M. Montrey,** S.M.'82, was at M.I.T. on May 3 to give a lecture for the students in Professor James Utterback's "Manufacturing/Technology Interface" class. In a recent phone conversation, he explained that Weyerhaeuser is undergoing some organizational changes at the moment, and Hank is involved in numerous task force meetings and dicussions for the Wood Products Division. . . . **Julian N. Nikolchev,** S.M.'83, was pictured recently in an article in *The SRI Journal*. He is manager of the Technology Planning Program at Stanford Research Institute and participated in a special seminar in January on a new Center for Economic Revitalization. The seminar was attended by leaders from government, industry, labor, and academia. Julian was planning a visit to Boston before the end of June and hoped to stop in at M.I.T. while here.—Jane Morse, Program Manager, M.I.T., Room E52-125, Cambridge, MA 02139

XVI

Aeronautics and Astronautics

Professor **Wesley L. Harris,** director of M.I.T.'s Helicopter Rotor Acoustics Group, has completed work as chairman of an Army Science Board *ad hoc* subgroup studying the design of the LHX (light helicopter experimental) that will be the prototype for a new fleet of military helicopters to be built in the 1990s. Two special questions for the group: the benefits and costs of increasing the helicopter's maximum speed capability; and the feasibility of incorporating "stealth" into the design. Among Harris' colleagues on the *ad hoc* group: **John Blair,** '54, director of research at Raytheon.

Robert F. Weiss, S.M.'59, writes, "Physical Sciences, Inc., continues to grow in its new location in Andover, Mass.—always looking for M.I.T. graduates. Avocation: completing Center Village, a unique elderly housing development in Lynnfield (as chairman of the project)." . . . **James W. Neighbours,** '41, reports, "Retired from the U.S. Navy and from Eastern Air Lines. Very busy with traveling and with local organizations, i.e.: Retired Officers Club, Historical Society, Parish Art Museum, and church activities. I am also a member of the M.I.T. Educational Council." . . . **Philip K. Chapman,** Sc.D.'67, is currently president of the L-5 Society, a board member of Space PAC, and a member of the Citizen's Advisory Council on National Space Policy.

Marc Genain, S.M.'75, has been since 1976 project manager for South East Asia of Societé Francaise d'Etude pour les Transports Urbains. . . . **Burton D. Figler,** S.M.'58, general manager of the Advanced Development Division at Aerodyne Research, Inc., Billerica, Mass., has taken on the added responsibility of organizing a new project office which will develop a commercial product for true three-dimensional viewing.

David L. Akin, '74, is now the Rockwell Assistant Professor of Aeronautics and Astronautics, occupying a chair funded at M.I.T. by Rockwell International Corp. Akin's doctorate is in the field of aerospace systems, and he had been involved in creating and teaching a new course in spacecraft flight dynamics and operations; his research is in the field of human productivity and automation in space, and he heads the Space Operations Group in the Space Systems Laboratory.

College and university students are marching toward computer terminals wherever they can find them—often faster than their professors. The students are right, says Professor **Sheila Widnall,** '60, in an editorial in *Science* (August 12, 1983). Observing such shifts in student choices as are happening at M.I.T., where nearly half of all engineering undergraduates are studying in the Department of Electrical Engineering and Computer Science, Professor Widnall writes, "Given the present state of the computer revolution, it is difficult to say that the students are making a mistake in wanting to be part of the action. . . . Once experienced, the expansion of personal intellectual power made available by the computer is not easily given up; it must have an important place in the teaching of science."

An Edgerton Professorship, intended to stimulate career development among young faculty, has been awarded to Assistant Professor **Joseph H. Haritonidis,** who joined the department at M.I.T. two years ago. Haritonidis' work is in the field of turbulence, and he holds an NSF research initiation grant in fluid mechanics.

Ralph G. Schmitt, S.M.'67, formerly vice-president of operations for R.G. Sloane Manufacturing Co. of California, has been named vice-president of manufacturing for Sweetheart Plastics, Inc., Wilmington, Mass., a division of Maryland Cup Corp. . . . **Edwin N. Myers,** S.M.'61, is currently serving as a member of the U.S. Delegation to the international export control (of high technology) review in Paris, as the technical expert on semiconductor technology and instrumentation. . . . **Jeffrey R. Kurland,** S.M.'70, is currently vice-president of the Telecommunications Systems Division at the First National Bank of Maryland, Baltimore. . . . **C.E. Biele, Jr.,** S.M.'65, recently became the deputy director of Navy Laboratories at the Naval Material Command, Washington, D.C.

Three deaths have been reported by the Alumni Association: **Mualla I. Sezel,** Sc.D.'50, assistant general director at the Turkish State Railroad, Ankara, Turkey, on January 19, 1983; **Aldro I. Lingard,** Sc.D.'50, a retired colonel in the U.S. Air Force of Valparaiso, Fla., on January 2, 1984; and **Robert S. Bush,** '37, of Miami, Fla., on March 6, 1984.

XVIII

Mathematics

Joseph J. Romm, (he's a graduate student in physics) in a series of alternatives to overcrowded Course VI in *The Tech:* "Mathematics is a great major. . . . The professors are among the finest lecturers—and poker players—in the Institute. . . . Course XVIII is for learning math, probability, and statistics, learning how to make a lot of money in games of chance, including the game of life, and learning why one is the loneliest number that you ever knew."

Two members of the department at M.I.T.—Professors **Rodolfo R. Rosales** and **Gunther A. Uhlman,** have been honored by the Alfred P. Sloan Foundation as Sloan Research Fellows; each receives a $25,000 grant for research support.

Three faculty members in the department at M.I.T. have recently authored books: Professor **George Lusztig,** *Characters of Reductive Groups of a Finite Field,* which will appear in the April 1984 issue of the *Annals of Mathematics Studies 107* (Princeton University Press); Professor **James Munkres,** *Elements of Algebraic Topology (Benjamin/Cummings, 1984); and Professor* **Sigurdur Helgason,** *Groups and Geometric Analysis, a graduate text in mathematics (Academic Press, 1984).*

Two alumni have received Presidential Young Investigator Awards from the National Science Foundation: **Stuart A. Geman,** Ph.D.'77, associate professor of applied mathematics at Brown University; and **Frank T. Leighton,** Ph.D.'78, assistant professor of applied mathematics at M.I.T. Geman's research focus is in the development of "a unified theoretical basis for computer image processing, with possible applications in the field of medical image processing and robotics"; Leighton's research efforts are in the field of theoretical computer science.

Francis D. Lowenthal, Ph.D.'74, is professor of logic at the University of Mons, Belgium, his special field is nonverbal communications in relation to the development of language and reasoning in children. . . . **Lynn Steen,** Ph.D.'65, professor of mathematics at St. Olaf College, Northfield, Minn., has been elected president of the Mathematical Association of America (MAA) for a two-year term commencing in January 1985; he will serve as president-elect for the remainder of 1984. The MAA "is the major organization dealing with collegiate mathematics and the largest of the dozen mathematics societies in America."

XXI

Humanities

Elizbieta Chodakowska, who has been a member of the faculty of the writing program for 10 years, is the second Thomas Meloy Professor of Rhetoric; she succeeds in that chair Irene Tayler, professor of literature. A native of Poland, Dr. Chodakowska came to the U.S. in the late 1960s to become a fellow at the Radcliffe Institute; her degrees in American literature are from the University of Warsaw. She is a leading author on Rosa Luxemburg, one of the prominent figures in radical Polish political activities, and author of *Kindergarten,* a widely-admired novel set in the Warsaw ghetto of World War II.

XXII

Nuclear Engineering

Shivaji S. Seth, Sc.D.'70, was appointed a senior fellow to the Advisory Committee on Reactor Safeguards (ACRS) of the U.S. Nuclear Regulatory Commission in May 1983.

Professor Norman C. Rasmussen, Ph.D.'56, who was head of the department at M.I.T. from 1975 to 1981, is now McAfee Professor of Engineering. The new chair, funded by a $1 million grant from Gulf Oil Corp., honors **Jerry McAfee,** Sc.D.'40, who retired in 1981, as Gulf's chairman and chief executive officer. Professor Rasmussen, an expert in nuclear reactor design and safety, is widely known as director of the safety study reported in the Nuclear Regulatory Commission's WASH-1400 report; **Herbert H. Richardson,** '53, associate dean of the School of Engineering, calls him "one of the most preeminent nuclear engineers in the nation."

Professor **David J. Rose,** Ph.D.'50, is a member of the Energy Engineering Board of the National Research Council/National Academy of Sciences Commission on Engineering and Technical Systems.

Obituaries

Kevin A. Lynch, 1918-1984: Analyst and Innovator of the Urban Scene

Kevin A. Lynch, '47, who taught urban design and the organization of cities at M.I.T. from 1949 until his retirement in 1980, died at his summer home on Martha's Vineyard on April 25. He was 66.

His professional partner, Stephen Carr, M.Arch.'61, called Professor Lynch "the greatest urban planner of our time," and he was, indeed, internationally known for the basic theories of how cities are perceived and organized by those who live in them. The author of seven books in the field, Professor Lynch was honored with the 50th Anniversary Award of the American Institute of Planners in 1967, the Allied Professions Medal of the American Institute of Architects in 1974, and the first Alfred Bettman Award, the most prestigious honor for planners, this year.

"More than any other person," said Professor Gary Hack, '65, head of the department, Professor Lynch "helped formulate the roles of planners and designers interested in improving the form and appearance of cities. He was an inspiration to a generation of city planners and designers."

Born in Chicago in 1918, Professor Lynch studied at Yale and Rensselaer before completing his degree at M.I.T.; during this period he also studied at Taliesin with Frank Lloyd Wright. After finishing at M.I.T. he was assistant director of planning for one year in Greensboro, N.C., and then returned to the Institute as an instructor. Since that time he was away from the Institute for only one year—for study in Italy under a Ford Fellowship in 1952.

Meanwhile, he maintained an extraordinary private practice, working on countless redevelopment projects in Greater Boston, Cleveland, Minneapolis, San Francisco, Los Angeles, San Diego, Columbia, Md., Washington, D.C., Dallas, Detroit, Phoenix, and Burlington, Vt.

John A. Bucsela, 1963-1984

John A. Bucsela, '84, the top-ranked senior in the Department of Mathematics, died suddenly on Massachusetts Ave. near Random Hall on April 3. He was the victim of a massive cardiac arrest, apparently the result of a congenital heart defect.

Bucsela received his M.I.T. degree posthumously at Commencement Exercises on June 4, and he was also initiated posthumously into Phi Beta Kappa by the M.I.T. chapter. He held a National Science Foundation fellowship for graduate study at the University of California in Berkeley in the fall.

Caroline M. Shillaber, 1909-1984

Caroline M. Shillaber, librarian in the Rotch Library from 1951 to 1963, died early this spring at her home in Wenham, Mass. She was 75.

Ms. Shillaber left M.I.T. to take a similar post at Harvard; during her M.I.T. tenure she completed a 100-year history of the School of Architecture and Planning that was widely admired throughout the profession.

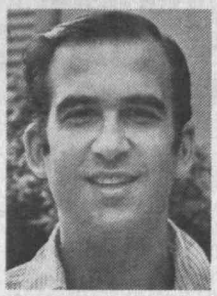
Deceased

Paul A. Cushman, '11; March 20, 1984; c/o Audrey Klein, 4124 Sunningdale NE, Albuquerque, N.M.
Mark C. Kinney, '11; 1983; 5-11 So. Main St., Mt. Vernon, Ohio.
Norman A. Lougee, '11; September 1982; 39 Homesdale Rd., Bronxville, N.Y.
Daniel J. Smith, '11; January 24, 1979; c/o McCourt, 36 Washington St., Newton, Mass.
Frederick P. Karns, '14; February 14, 1984; 1242 Elk St., Franklin, Penn.
Walter H. Monahan, '14; 1983; 103 Rock Island Rd., Quincy, Mass.
Edward Steere, '14; 1982.
Henry J. Lucey, '15; January 21, 1984; 25 Paris St., PO Box 203, Norway, Maine.
John T. Kiley, '18; April 7, 1984; 2 Kimball Rd., Arlington, Mass.
Sherman A. MacGregor, '18; February 14, 1984; VA Center Hospital, Bay Pines, Fla.
Lester N. Woodland, '18; April 3, 1984; 49 Ardsmoor Rd., Melrose, Mass.
John S. Carter, '19; January 24, 1984; Groton Regency, 1145 Poquonnock Rd., Groton, Conn.
Henry L. Cassidy, '19; 1975; 223 El Viento, Los Alamos, N.M.

George B. Hirsch, '19; July 17, 1983; 156 Harper Terr., Cedar Grove, N.J.
Donald S. Graves, '20; February 3, 1984; 549 Woodland Ct., Duarte, Calif.
Edward J. McCarthy, '20; 1981; 403 No. Frederick Ave., Oelwein, Iowa.
Edward L. Young, '21; December 4, 1983; 527 Wychwood Rd., Westfield, N.J.
Frederick J. Burt, '22; January 21, 1984; 24 Crescent Ln., Colorado Springs, Col.
William P. Dickerman, '22; March 15, 1984; 30 Ashland St., Taunton, Mass.
William B. Gurney, '23; November 26, 1983; 1439 Arlington Ave., Baton Rouge, La.
Mrs. Myles Morgan, '23; 1983; 450 South Rd., c/o George White, Holden, Mass.
John B. Nason, Jr., '23; April 1, 1984; 1167 Norsam Rd., Gladwyne, Penn.
Ranald V. Giles, '24; January 31, 1984; 2050 SW 10 Court, B-324, Delray Beach, Fla.
Roger L. Griffin, '24; February 17, 1984; 3 Hamilton House, Beverly Common, Beverly, Mass.
Max L. Ilfeld, '24; March 23, 1984; 600 Alcade SW, Apt. 9A, Albuquerque, N.M.
Denton Massey, '24; January 25, 1984; 102 Fountain St., Cambridge, Ont., Canada.
Omar C. Hopkins, '25; March 12, 1984; 9945 Ironwood Dr., Sun City, Ariz.
Frank D. Klein, '25; March 6, 1984; 118 Stratford, Ventura, Calif.
Charles E. Norton, '25; January 12, 1982; 4939 Lakeridge Terr. Ln., Reno, N.Y.
Robert L. Rockefeller, '25; May 6, 1982; 1920 S Ocean Dr. Apt. 801, Ft. Lauderdale, Fla.
Virgil W. Ware, '25; November 20, 1983; 101 Avonbrook Rd., Wallingford, Penn.
Saul Londino, '27; January 31, 1984; c/o The Londino Stone Co., Inc., 3621 Provost Ave., Bronx, N.Y.
Gjon Mili, '27; 1984; 344 3rd Ave., New York, N.Y.
John P. Connelly, '28; April 10, 1984; 116 Oak Ridge Dr., York, Penn.
Walter J. Nock, '28; March 3, 1983; John Knox Village, 1300 S Border Ave. No. 213, Weslaco, Tex.
John F. Dexter, '29; March 22, 1984; 671 SW 6th St. No. 302, Pompano Beach, Fla.
Charles W. Meadows, '29; May 17, 1983; 2129 W New Haven Ave., W. Melbourne, Fla.
Morris Smith, '29; 1984; R Bar Kochbah 10/8, Jerusalem, Israel.
Mahlon Richard Boyer, '30; January 29, 1984; The Forge Rd. No. 1, Pine Grove, Penn.
Thomas W. Connor, '30; April 16, 1983; 27 Muzzey St., Lexington, Mass.
Lawrence Harris, '30; September 7, 1983; 140 East 2nd St., Brooklyn, N.Y.
Leroy F. Marek, '30; March 11, 1984; Fairlawn Nursing Home, 265 Lowell St., Lexington, Mass.
John S. Patrick, '30; June 20, 1983; 3 Via Nazario Sauro, Menaggio Como, Italy.
C. Haskell Small, '30; April 17, 1984; 4100 Cathedral Ave. NW No. 617, Washington, D.C.
Phillip F. Frink, '31; March 21, 1984; 2000 43rd Ave., E No. 302, Seattle, Wash.
Charles W. Isselhardt, '32; 1978.
Howard R. Pyle, '32; March 27, 1983; Rt 2 Box 348, Cornelius, Ore.
Albert S. Rice, '32; September 1, 1983; 504 Windsor Rd., Savannah, Ga.
Leroy Smith, Jr., '32; January 28, 1984; 1441 S Paso Real No. 138, Rowland Heights, Calif.
Edgar M. Pierce, '33; November 1982; 734 Alpine Dr., Milford, Ohio.
Rein A. Wilson, '33; December 20, 1983; 94 Line St., Somerville, Mass.
Mrs. Charles E. Dawson, '34; January 14, 1984; c/o Fedder, 40 W 936 Bridle Creek Dr., St. Charles, Ill.
John H. Francis, '35; November 22, 1983; 65 Newark Ave., Bloomfield, N.J.
Robert A. Hill, '35; January 29, 1984; 109 Northway, Greenbelt, Md.
George J. Platt, '35; June 1982; Tiffany Gardens East, 1600 N. Ocean Blvd. No. 504, Pompano Beach, Fla.
John R. Vickery, Jr., '35; February 13, 1984; 17 Hibiscus Rd., Clearwater, Fla.
Richard S. Robinson, '36; October 9, 1983; 10 Bay State Rd., Belmont, Mass.
Louis A. Testa, '36; 1984; c/o Donatelli Bldg. Co., Inc., 1900 Mineral Spring Ave., Providence, R.I.
Robert S. Bush, '37; March 6, 1984; 7910 SW 52nd Ave., Miami, Fla.
Clifford S. Lord, '37; 1983; 215 Mackay St., Unit 10, Ottawa, Ontario, Canada.
Paul W. Branning, '38; 1984; Ave. Atlantic 2150/801, Rio De Janeiro, Brazil.
William M. Harp, '38; December 27, 1983; 115 Crow Rd., Baytown, Tex.
Alfred C.W. Louie, '38; 1982; Kingsford Gardens C-2 12/F, 212 Tin Hau Temple Rd., Hong Kong.
Ralph S. Woollett, '39; March 14, 1984; 292 Pequot Ave., New London, Conn.
John McMullen, '40; December 28, 1983; 931 Rio St Johns Dr., Jacksonville, Fla.
William Menoher, '40; October 23, 1978; PO Box 1570, Fort Pierce, Fla.
Albert W, Schlechten, '40; February 16, 1984; 1904 Pinal Rd., Golden, Col.
Daniel Lynn Carroll, Jr., '41; June 26, 1981; 7786 Sierra Mar Dr., La Jolla, Calif.
Leslie Corsa, '41; March 2, 1984; 3543 Miller Rd., Ann Arbor, Mich.
Horace H. Binney, '44; January 8, 1983; 986 Sweetbriar Dr., c/o Ferrone, Deltona, Fla.
Halil E. Dagdevirenoglu, '44; April 15, 1983; Istanbul Amerikan, Robert Lisesi Lojmani, Arnavutkov, Istanbul, Turkey.
Richard M. Weedon, '44; February 27, 1984; 6024 E. Cactus Wren Rd., Paradise Valley, Ariz.
Alfred A. D'Addieco, '46; March 11, 1984; 3514 Calvano Dr., Grand Island, N.Y.
Edward A. Cote, '47; December 26, 1983; 4511 Brafferton, Bloomfield Hills, Mich.
Edmond W. Holroyd, Jr., '47; November 1, 1983; 20 Old Farm Circle, Pittsford, N.Y.
Guy F. Boucher, '49; April 19, 1983; 18 Hunting St., Wellesley, Mass.
Herbert Levick, '50; March 8, 1984; 132 Signal Hill Rd., Wilton, Conn.
Carl F. Huntsinger, '51; 1982; 1071 Rancho Dr., Ojai, Calif.
Manuel Perez Marcano, '51; May 10, 1977; Edificio Imsbanca 53, Santa Cafilla A Milares, Caracas, Venezuela.
Milton J. Merrin, Jr., '51; March 13, 1983; 5131 SE Logus Rd., Milwaukie, Ore.
Clinton B. Seeley, '51; March 6, 1984; 21 Sheridan Rd., Andover, Mass.
Duncan C. Bryan, '52; October 3, 1980; PO Box 109, Northfield, Vt.
Pao Tan Hsu, '52; April 10, 1981; 11 Bencliffe Circle, Auburndale, Mass.
Helmut J. Maier, '54; January 21, 1984; 324 Overdale Dr., Forrest Hills, Penn.
Dan T. Rogers, '54; June 21, 1980; 2013 South Davis Blvd., Bountiful, Utah.
Donald B. Russell, '55; February 11, 1984; 8526 Northeast 26th St., Bellevue, Wash.
Julius B. Bernsteins, '56; November 21, 1983; PO Box 43, Gloucester, Mass.
William H. Reinmuth, '57; December 18, 1983; 420 Riverside Dr., New York, N.Y.
Karl W. Hahn, Jr., '59; March 15, 1979; 29 Virginia St., Dorchester, Mass.
Harold Levy, '60; March 25, 1984; 87 Lorimer Rd., Belmont, Mass.
Walter N. Vaughan, '61; December 16, 1983; 8 Caledonia Ave., Guelph, Ontario, Canada.
Walter C. Hinds, Jr., '62; March 31, 1984; c/o Hinds Associates, Inc., 27 Whispering Pine, Sudbury, Mass.
Lester G. Crunkleton, '63; January 21, 1984; 1291 Raleigh Ct., Tarpon Springs, Fla.
Teuvo J. Santala, '69; October 29, 1979; 118 Berwick Rd., Attleboro, Mass.
Richard P. Cramer, '74; March 20, 1984; 13 Renee Pl., Massapequa Park, N.Y.
Arnaldo A.T. Ribeiro, '76; November 9, 1982.
Jonah L. Garbus, '81; December 1982; 3977 E Sedgwick Ave., Bronx, N.Y.
Pramod Manaloor, '81; 1984; 1039 Commonwealth Ave. No. 20, Boston, Mass.
Jon A. Bucsela, '84; April 3, 1984; 282-290 Massachusetts Ave., Cambridge, Mass.
Keith T. Ennis, '84; February 29, 1984; 253 Commonwealth Ave., Boston, Mass.

Las Vegas Month

Puzzle Corner/Allan Gottlieb



Allan J. Gottlieb, '67, is associate research professor at the Courant Institute of Mathematical Sciences of New York University; he studied mathematics at M.I.T. and Brandeis. Send problems, solutions, and comments to him at the Courant Institute, New York University, 251 Mercer St., New York, N.Y. 10012.

I am honored to learn that the well-known Japanese puzzler Nob. Yoshigahara has selected me as World's Puzzler No. 6 in his puzzle column in *Quark*, a leading Japanese science magazine. Since the problems and solutions that appear in "Puzzle Corner" are contributions from you the readers, I know who deserves the honor.

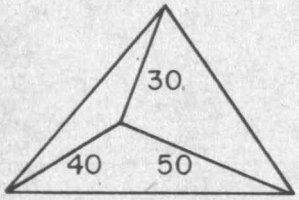
Problems

JUL 1. We begin with a bridge problem from Doug Van Patten:

	♠ J 10 9 8 6 3 ♥ A J 5 ♦ K ♣ A 9 3	
♠ Q 4 ♥ K 7 3 ♦ 10 7 6 4 ♣ Q J 10 7		♠ 7 5 2 ♥ Q 9 4 2 ♦ Q 5 3 2 ♣ 5 4
	♠ A K ♥ 10 8 6 ♦ A J 9 8 ♣ K 8 6 2	

You are South and open one no-trump. Your partner falls in love with her hand, transfers in spades, and puts you in a highly optimistic six-spade contract. Can you justify her faith in your declarer play? Opening lead: ♣Q.

JUL 2. A geometry problem that Van Ling attributes to Walfred Lester:



Given an equilateral triangle with the indicated lines and lengths, determine the length of a side.

JUL 3. Dave Evans wants you to help him navigate in 4-space:
If a chess cube is placed in the corner square of a 3 × 3 chessboard, there are six distinct shortest paths (i.e., combinations of vertical and horizontal moves which do not backtrack) to the diagonally opposite corner. How many distinct shortest paths exist from a corner cell of a 3 × 3 × 3 cube to the cell opposite along a space diagonal, assuming movement parallel to the three axes? How about in a 3 × 3 × 3 × 3 hybercube?

JUL 4. Don't play craps with Albert Mullin! As a student of "loading up" the dice, he writes:
Show that it is physically impossible to "load" a pair of ordinary dice such that each of the eleven possible rolls is equally likely to occur. (Generalize to the other four regular polyhedra—e.g., the possible rolls of a pair of regular dodecahedra.)

JUL 5. This must be Las Vegas month, as Richard Jones wants to study betting on roulette:
Is it wise to bet conservatively (making many small bets) instead of making a few large bets? Specifically, a man gambles $100.00 a night by betting on black at roulette. Usually he places a single $100.00 wager and quits for the night. Since the wheel has only a single zero and pays even money, he has an 18/37 chance of winning $100.00. Suppose, instead, he starts with $100.00 but makes $1.00 bets until he runs out of money or is up $100.00. What is the probability that he will be a winner after a night of gambling?

Speed Department

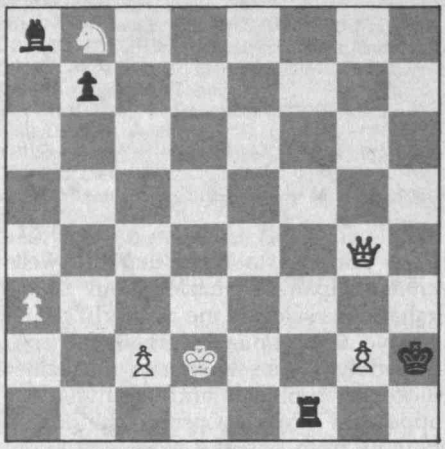
SD 1. Inspired by Emmett Duffy, Phelps Meaker asks for the last four digits of 7^{7777}, 7^{5555}, and 7^{4444}, and the last three digits of 13^{1313}.

SD2. David Evans wonders if there are two people in San Francisco that have the same number of hairs on their heads. (As an aside, we just returned from a trip to San Francisco, which David Gottlieb pronounced KooKoo. He charmed the entire staff of a Chinese

restaurant when he walked up to the owner, looked at me, and said, "This man KooKoo.")

Solutions

F/M 1. White to mate in two:



John Bobbitt first shows that the world is upside down and then finds the appropriate underpromotion:

Why the peculiar P-B-N combination in the upper left corner? The answer is that it gives a clue as to what direction White and Black are moving. The only way the Black bishop could be trapped behind the pawn is for Black to be moving up the board. Given that information, the winning move for White is P×R with the pawn being replaced by a bishop. (A queen or rook leads to a stalemate, a knight leads to a chase around the board.) Black is forced to reply K-R1 and Whites's Q-N7 mate finishes the game.

Also solved by David Krohn, Richard Hess, Matthew Fountain, John Glenn, Ronald Raines, Craig Presson, Lester Steffens, and the proposer, Daniel Seidman.

F/M 2. Three missionaries and three cannibals are on the left bank of a river and have to cross to the right bank using a boat that can hold two people. At least one person must be in the boat in order to move it from one side of the river to the other. On each bank, the missionaries must never be in a situation where they are outnumbered by the cannibals. How do all six people get across?

Naomi Markovitz has sent us the following solution:

Left bank	*Boat*	*Right bank*
MMMCCC		
MMMC	CC →	
MMMC		CC
MMMC	← C	C
MMMCC		C
MMM	CC →	C
MMM		CCC
MMM	← C	CC
MMMC		CC
MC	MM →	CC
MC		MMCC
MC	← MC	MC
MMCC		MC
CC	MM →	MC
CC		MMMC
CC	← C	MMM
CCC		MMM
C	CC →	MMM
C		MMMCC
C	← C	MMMC
CC		MMMC
	CC →	MMMC
		MMMCCC

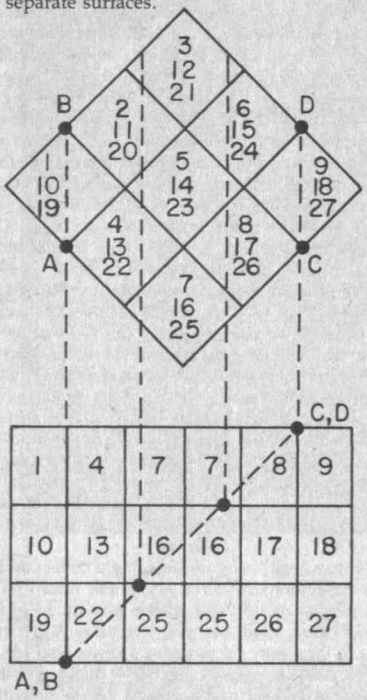
Also solved by Ronald Raines, Matthew Fountain, Richard Hess, David Krohn, Angel Silva,

Harry Zaremba, John Bobbitt, Winslow Hartford, John Woolston, Avi Ornstein, Alan Robock, Mary Lindenberg, and Mitchell Gaynor.

F/M 3. What is the largest number of triangles that can be produced by passing a plane through a cube that is divided into 27 subcubes?

Although not stated, the intent, as noted by Matthew Fountain, was that the original cube be divided into 27 *equal* subcubes. Harry Zaremba and Tom Harriman each found 100 triangles. Mr. Zaremba's pictorial-tabular solution is given below; if the printer could handle it (which he can't, because it involves three colors as well as several dashed and dotted lines in black) we'd also publish Mr. Harriman's picture.

As shown in the figures, the subcubes are numbered from 1 to 9 at the top, 10 to 18 at the center, and 19 to 27 at the bottom. To obtain the number of triangles, it is assumed all abutting faces of the subcubes and sloped cuts by the plane represent two separate surfaces.



Let the plane pass through points A, B, C, and D. Nineteen subcubes will be cut by the plane. The number of triangles produced on the top, bottom, side, and sloped faces of the cubes is tabulated below. A total of *100 triangles* is formed.

Cube number	*Top*	*Bottom*	*Sides*	*Slope*	
3		1	2	2	
5		1	2	2	
6		1	4		
7		1	2	2	
8		1	4		
9	2		2	2	
11		1	2	2	
12	1	1	4		
13		1	2	2	
14	1	1	4		
Total	**4**	**9**	**28**	**12**	53
15	1		2	2	
16	1	1	4		
17	1		2	2	
19		2	2	2	
20	1		4		
21	1		2	2	
22	1		4		
23	1		2	2	
25	1		2	2	
Total	**8**	**3**	**24**	**12**	47
					100

	Average number of purchases required to decrease N over range shown, as determined by 1,000 trials					
N starts at	80	79	69	68	57	56
N ends at or below	70	70	60	60	50	50
Number of purchases	7.196	6.540	7.670	6.782	7.227	6.144
Cost of purchases	$1.439	$1.308	$1.534	$1.356	$1.445	$1.229

Also solved by Richard Hess and the proposer, Lester Steffens.

F/M 4. Find a four-digit number whose square is an eight-digit number with the middle four digits all 0; i.e., $(abcd)^2 = ef000gh$.

Angel Silva found $6245^2 = 39000025$.

Also solved by R. Duff Ginter, Richard Hess, Alan Robock, Avi Ornstein, John Woolston, Winslow Hartford, John Bobbitt, Harry Zaremba, David Krohn, Matthew Fountain, John Glenn, Jeff Schoenwald, G. Zartarian, Richard Marks, John Jordan, Frank Carbin, Jesse Spencer, Joseph Horton, Frank Norton, George Piotrowski, Donald Rosen, Steve Feldman, and the proposer, Smith Turner.

F/M 5. There are 260 baseball stickers in a set and they are purchased in groups of five for 20 cents. You can also send away for groups of 10 (specific numbers) for $1 plus 20 cents postage (plus it costs 20 cents to mail). When is the optimal time to send away? What is the proper barter philosophy to have with friends?

The following solution is from Mattew Fountain: The collector who does not trade and simply wishes to advance toward completion of one full set should send away for one when he has acquired 186 different stickers. If he intends to complete the set, he should send away when his total reaches 180. If his total skips 180, he should wait till 190. If his total also skips both 190 and 191, he should wait until 200. If his total also skips 200, 201, 202, and 203, he should wait till reaching 210 before sending away.

The optimum barter philosophy with friends is that of cooperation and patience. Friends should exchange stickers, one for one, whenever it helps one and does not hurt the other. The one with the fewest stickers should make the next purchase. As long as they as a group lack 75 different stickers they should not send away. Even then they can postpone sending away by inducting new members into their group. When they do send away, orders are placed to cover the needs of the group, with the cost of the unused portion of the last group of ten stickers divided evenly among the group of members.

The above statements are based on the following reasoning. The phrase "optimum time to send away" is taken to apply to the purchase of one group of 10 stickers, and "plus it costs 20 cents to mail" refers to the cost of requesting one group. This makes the unit cost of the specific stickers 14 cents. When N stickers are missing, the number of missing stickers expected in a 20-cent purchase of five different, unspecified stickers is (5/260)N, making their expected unit cost 20/(N/52) cents. When N = 74.2 their expected unit cost is 14 cents, the same as those bought by mail. When N = 80 their cost is 13 cents. When N = 70 their cost is 14.9 cents. As buying 74 specific stickers by mail entails buying 80 stickers, one can save about 78 cents on the average by starting mail purchases when N is either 80 or 70, instead of 74.

While of trivial importance, it is interesting to determine which value of N is best for starting buying by mail. I programmed my computer to run a Monte Carlo test of 1,000 trials of how many 20-cent purchases would be required to decrease N from 80 to 70. As the computer tallied each simulated purchase, it decreased the trial N by an integer ranging from 0 to 5, the integer being selected by a random process weighted to assure that each integer had the same probability of being selected as that the integer number of wanted stickers would appear in a 20-cent purchase, the probabilities changing as N decreases. Each trial ended when N decreased to no more than 70. I then repeated the test starting with other values of N, but always ending each trial when N decreased to or below an even multiple of ten. The results are shown above (*box*). When the lone collector sends away at N = 80, his expected savings are not the difference between $1.439 and $1.40, for in doing so he forfeits his chance of skipping N = 70 and N = 69. Should he reach N = 68, he would continue on to N = 60 with the expected saving of 4.4 cents. And should he skip to N = 67 or N = 66, his expected savings would be about 22 cents or 40 cents, respectively. To determine the frequency that he would skip certain values of N, I had my computer rerun my program, starting with N = 80, but increasing the number of trials to 10,000. The frequencies that N reached 70, 69, 68, 67, and 66 were .5832, .3104, .0927, .0122, and .0015, respectively. The chance of skipping past N = 70 is therefore worth about $(4.4)(.0927)+(22)(.0122)+(40)(.0015) = 0.736$ cents. The expected savings from sending away at N = 80 is 4.4 − .74 = 3.66 cents.

A cheap "fair" way of acquiring a collection is to offer collectors who have just made their first 20-cent purchases, "If you let me buy up to four of your stickers, I will pay you 4 cents each. To make it more than fair, I'll pay you 4 cents also for any sticker you get in your next five-sticker purchase that gives you a duplicate. You'll end up with at least five, and probably more, different stickers at a cost of 4 cents each." This scheme is not entirely fair, as those who practice it do not acquire the normal number of duplicates that are useful to others. This is the reason why when friends cooperate they should trade rather than sell, and why the one with the least stickers should do the buying. It evens up the distribution of excess duplicate stickers.

Also solved by David Krohn, Richard Hess, Howard Wagner, and Frank Carbin.

Better Late than Never

1982 OCT 3. Howard Wagner has responded.

N/D 2, N/D 3, N/D 4. Naomi Markovitz has responded.

1984 JAN 1. Tom Harriman and G. Zartarian have responded.

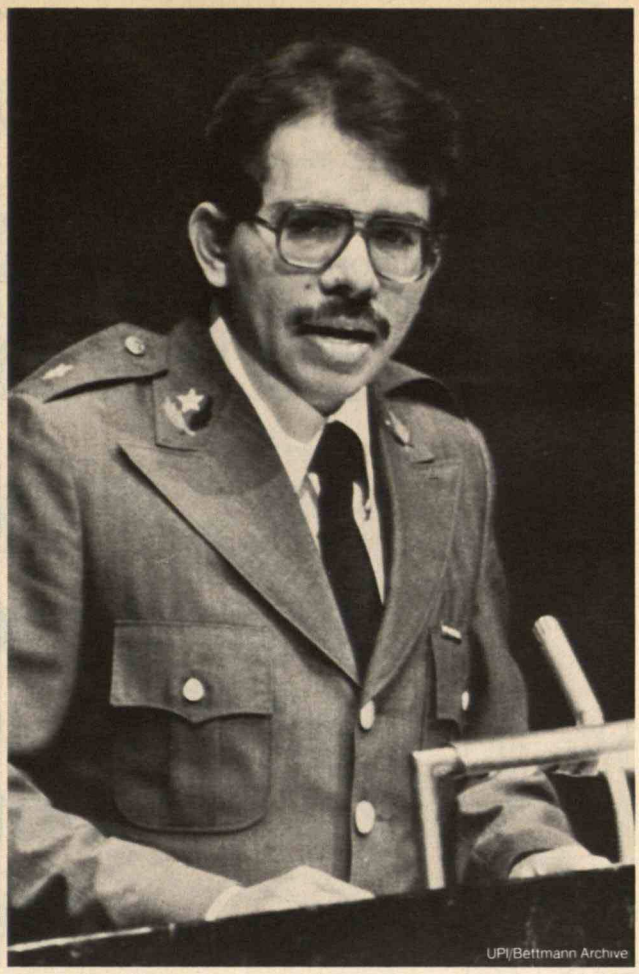
JAN 2, JAN 3. Tom Harriman has responded.

F/M SD2. Jeff Schoenwald, Angel Silva, and George Downie note that the side of the tank is 5 decimeters in length.

Proposers' Solutions to Speed Problems

SD1. 9207, 1943, 6401, and 253.

SD2. Yes, by the pigeon-hole principle, since the number of hairs is under 100,000.



UPI/Bettmann Archive

QUICK. WHOSE SIDE ARE WE ON?

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Scientists now know that food affects the brain and that the brain, in turn, tells us what to eat. This information may enable us to eat our way out of obesity and someday treat serious disorders such as Alzheimer's disease and depression.

The Ultimate Head Waiter: How the Brain Controls Diet

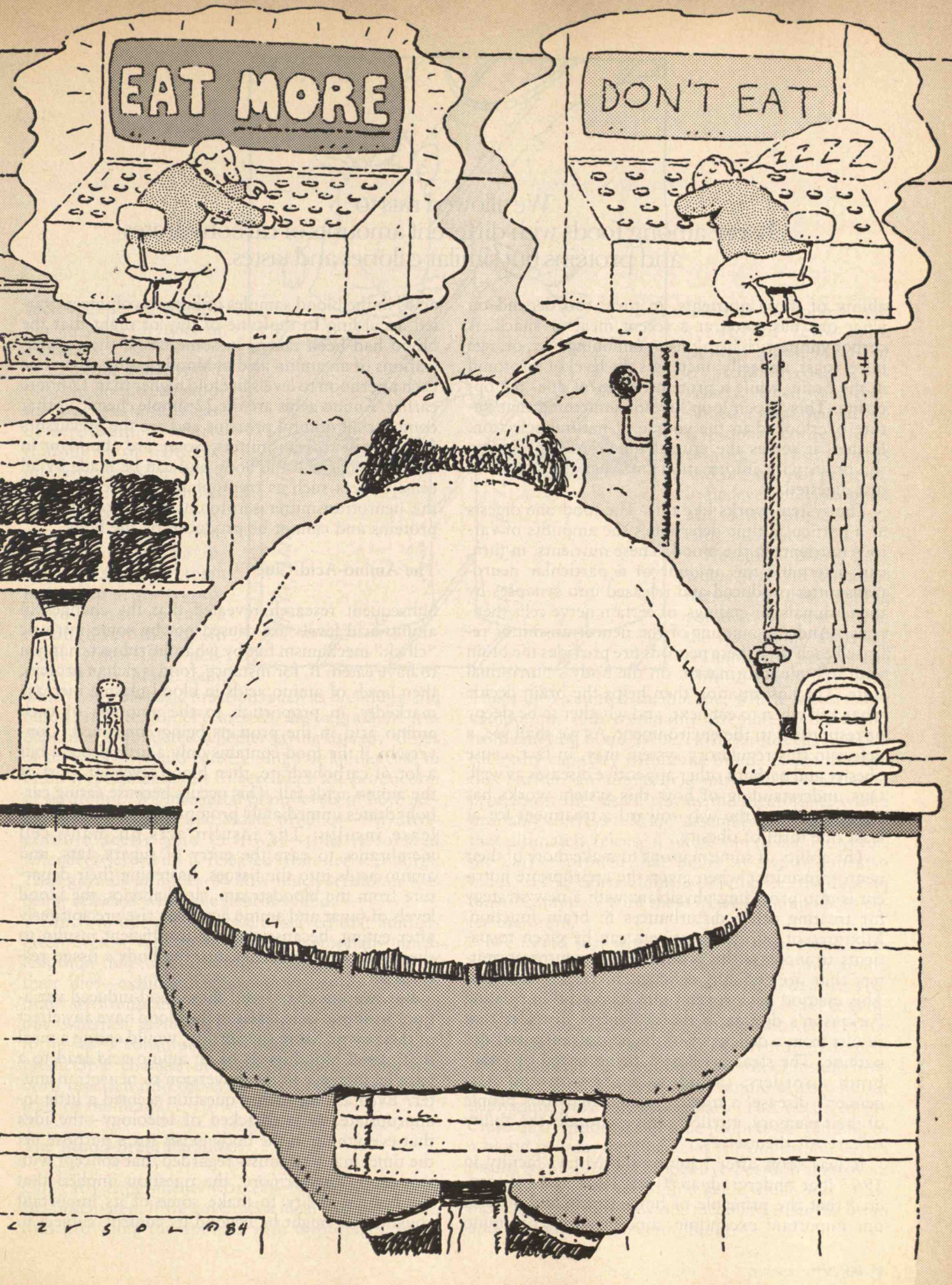
BY RICHARD J. WURTMAN

When I was a medical student in the late 1950s, I was taught that a simple rule governed the workings of the entire body. That rule, called homeostasis, stated that the constituents of blood, along with physical characteristics such as blood pressure and temperature, were maintained within a narrow range by feedback loops. These closed-loop systems would simply not allow blood pressure, for example, to rise or fall beyond a certain set point. However, the systems could sometimes be interrupted by stress or disease, and the set points could vary somewhat with the time of day. For instance, body temperature is normally about a degree lower at 6 A.M. than at 6 P.M. Still, it was an article of faith that no important compound or process in the body could go unregulated. That rule included the processes by which the body converts nutrients from the diet into the chemicals it uses to transmit messages.

These chemical messengers act in two ways. Some transmit a specific message from one nerve cell across a narrow gap known as a synapse to another nerve cell; these are known as neurotransmitters. Other chemicals, called hormones, flood the bloodstream, carrying messages to all parts of the body. Together, these chemicals provide a remarkably effective communication system that permits the brain to control behavior as well as most bodily functions and growth. Under the rule of homeostasis, the rate at which the body produces these chemicals from nutrients would not be affected by the timing of a person's meals. For example, many of the body's hormones, such as the testosterone or estrogen that regulate sexual development, are made from cholesterol. Yet scientists had (and still have) no reason to think that eating a cholesterol-rich meal would increase the production of either.

However, my associates and I have found that homeostasis does not govern the production of some of the most important neurotransmitters. The frequencies with which nerve cells make and release acetylcholine, serotonin, norepinephrine, and some other neurotransmitters are not controlled by closed feedback loops. Their production depends very much on the amount of certain nutrients that happen to be available at a particular time. And the avail-

ILLUSTRATIONS: JIM CARSON


EAT MORE
DON'T EAT
ZZZZ

We allowed rats to choose among foods with different amounts of carbohydrates and proteins but similar calories and tastes.

ability of those nutrients, in turn, can depend on what one has eaten at a recent meal or snack. A carbohydrate-rich breakfast (containing, say, orange juice, toast, and jelly) increases the level of serotonin in the brain, while a protein-rich meal does the opposite. This "open loop" is not something that nature overlooked in the course of natural selection. Rather, it serves the crucial function of providing the brain with information on what the body has just digested.

The system works like this. The food one digests at a particular time determines the amounts of various nutrients in the blood. These nutrients, in turn, can determine the amount of a particular neurotransmitter produced and released into synapses by the terminals, or endings, of certain nerve cells (neurons). And the amount of the neurotransmitter released each time these neurons fire provides the brain with tell-tale information on the body's nutritional state. This information then helps the brain decide what and when to eat next, and whether to be sleepy or responsive to the environment. As we shall see, a defect in this regulatory system may, in fact, cause obesity and perhaps other appetitive diseases as well. Our understanding of how this system works has already pointed the way toward a treatment for at least one form of obesity.

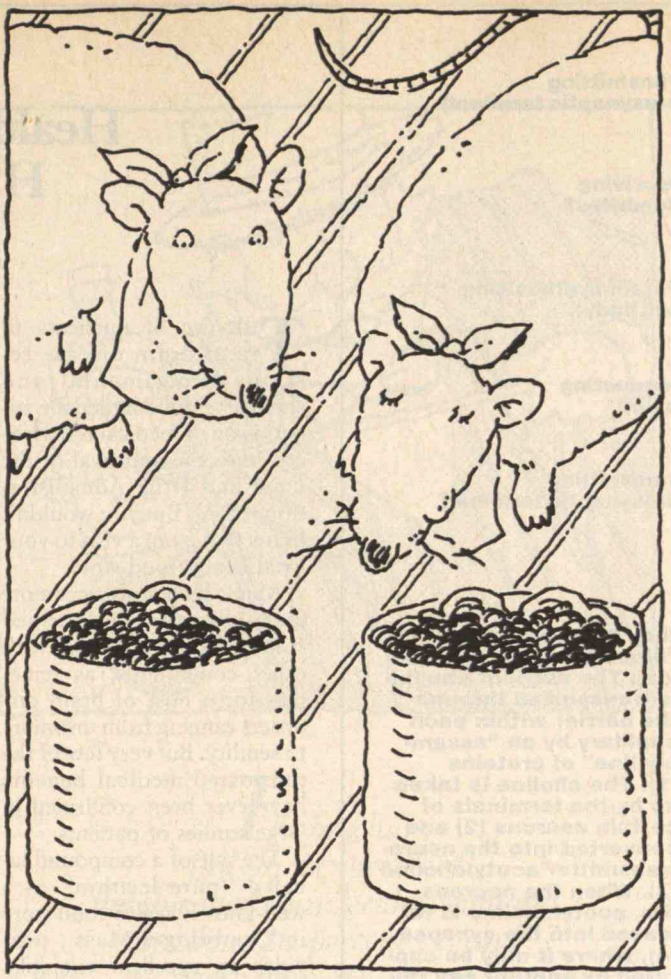
The ability of some neurons to make more of their neurotransmitter when given the appropriate nutrient is also providing physicians with a new strategy for treating other disturbances in brain function. Mixtures of purified nutrients can be given to patients to increase the production of neurotransmitters that are thought deficient in certain diseases. This method has proven quite successful in treating Parkinson's disease, a motor-control disorder that results from a deficiency of the neurotransmitter dopamine. The strategy is now being tested on other brain disorders, including depression and Alzheimer's disease, a tragic disorder that robs people of their memory, intellect, and eventually the ability to care for themselves.

It was soon after I joined the M.I.T. faculty in 1967 that undergraduate Chris Rose and I discovered that the principle of homeostasis had at least one important exception: concentrations of amino acids in the blood samples of human volunteers varied according to the time of day or night that the blood had been taken. In some cases, the concentrations of an amino acid in blood plasma might rise each afternoon to levels fivefold higher than 12 hours earlier. Amino acids are the 22 simple chemicals that compose all natural proteins and are the precursors for most neurotransmitters. Some are abundant in food proteins and the body and can be made by all cells. Others such as tryptophan, the precursor for the neurotransmitter serotonin, are scarce in food proteins and cannot be produced by the body.

The Amino-Acid Clue

Subsequent research revealed that the changes in amino-acid levels are caused not by some intrinsic "clock" mechanism but by what the subjects happen to have eaten. If, for instance, food is rich in protein, then levels of amino acids in blood plasma increase markedly, in proportion to the amounts of each amino acid in the proteins being consumed. Conversely, if the food contains only a little protein but a lot of carbohydrate, then blood levels of most of the amino acids fall. This occurs because eating carbohydrates immediately prompts the pancreas to release insulin. The insulin acts on many cell membranes to ease the entry of sugars, fats, and amino acids into the tissues, hastening their departure from the bloodstream. (In diabetics, the blood levels of sugar and amino acids can rise precipitously after eating, because there is insufficient insulin to shepherd these nutrients into the body's tissue reservoirs.)

But, we wondered, did these food-induced variations in amino-acid levels in the blood have any effect of their own? More specifically, would eating a meal that raised blood levels of an amino acid lead to a parallel increase in its conversion to neurotransmitter? Even asking such a question seemed a little inappropriate, as it smacked of teleology—the idea that everything in the body exists for a purpose. At the time, many scientists regarded that concept with suspicion. Furthermore, the question implied that the brain's ability to make some of its important constituents might be beyond its control, subject to



such vagaries as whether one ate pizza for lunch on Tuesdays.

To probe this hypothesis, we decided to study the synthesis and release of serotonin, a neurotransmitter of particular interest because its levels in the brain were known to be affected by psychoactive drugs. It was also known to be involved in sleep. Serotonin is formed from tryptophan and released throughout the brain from terminals of neurons in the brain stem, which controls basic functions such as breathing and blood pressure. John Fernstrom, then a graduate student, and I wondered whether giving rats low doses of tryptophan could cause enough of an increase in brain tryptophan levels to accelerate the production of serotonin. We measured brain levels of both serotonin and a particular waste product—5-hydroxyindole acetic acid (5-HIAA)—that is formed whenever serotonin is released from nerve endings. That gave us an index of how much serotonin was being released when the neurons fired.

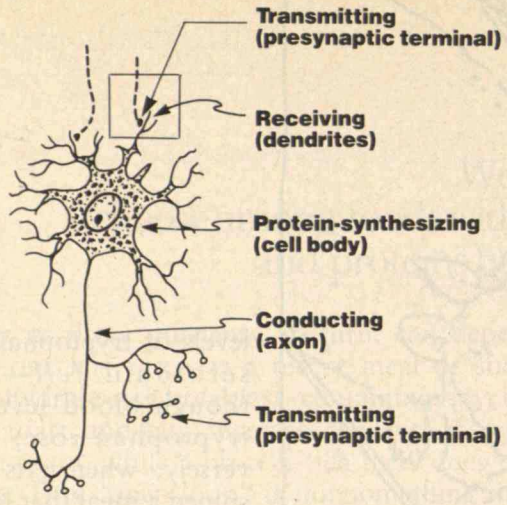
Much to our pleasure, we observed that animals given even a very small dose of trytophan—much less than they would normally consume as part of their diet—exhibited robust increases in levels of brain serotonin and 5-HIAA. We next decided to find out whether giving tryptophan in its "natural" form—as a constituent of food—could also cause predictable changes in brain serotonin. Thus was born research into the effects of food on the chemicals of the brain.

The Blood-Brain Paradox

Our early experiments worked—but not in the way we anticipated. If we gave rats a meal rich in protein, thus providing the animals with tryptophan, brain levels of tryptophan and serotonin *fell*—even though blood levels of tryptophan rose. Conversely, when rats consumed a meal that lacked tryptophan entirely (containing carbohydrates and fats but not protein), brain levels of tryptophan and serotonin consistently increased.

Research done elsewhere revealed an explanation for this seeming paradox: it stems from the way amino acids are transported across the "blood-brain barrier." This much-vaunted membrane, which keeps many compounds that commonly circulate in the blood from entering brain tissue, exists in the cells that line each tiny capillary within the brain. To get through this barrier, an amino acid must bind to a carrier protein on the inside rim of the membrane, which probably conveys it to an "assembly line" of proteins that ultimately release it into brain tissue. However, the carrier protein that binds to tryptophan also binds to five other amino acids; hence, tryptophan must "compete" with these other compounds to enter the brain.

We found that when rats ate protein, blood tryptophan levels rose less than the levels of other amino acids consumed, which are more abundant in protein. Thus, tryptophan's access to the brain was diminished, and serotonin production slowed. On the other hand, when rats ate a carbohydrate-rich, protein-free meal, the resulting secretion of insulin lowered the blood levels of other amino acids without depressing those of tryptophan. (This occurred because of tryptophan's unique property of binding to a blood protein that insulates it from insulin.) As a result, tryptophan's competitive position improved, allowing more of the amino acid (which was in the bloodstream from previous meals) to enter the brain and be converted to serotonin.



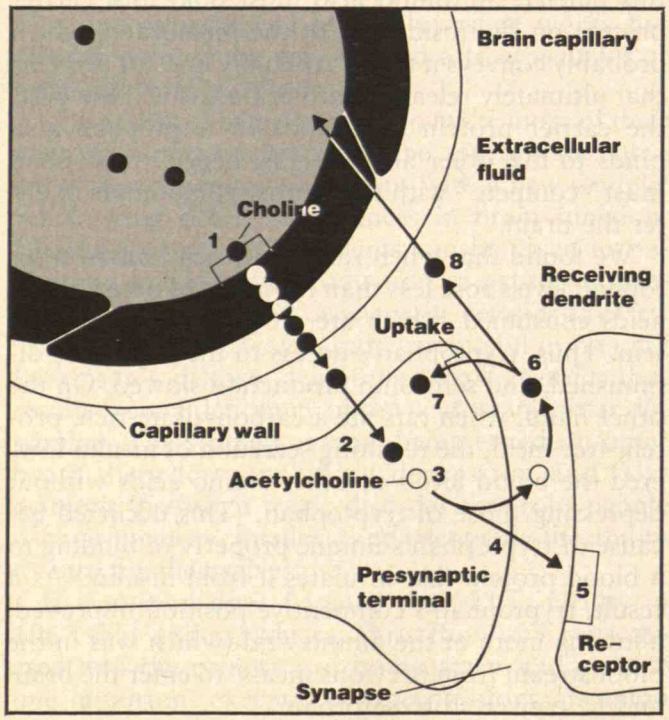
Nerve cells transmit information by firing chemical signals (neurotransmitters) across a narrow synapse. Above: The neurotransmitter jumps from the presynaptic terminal of one cell to the dendrite branches of another. The message is converted into an electrical impulse, which is carried down a long channel, or axon that branches out into hundreds of nerve endings. The impulse is then converted back into a chemical for transmission to other cells. Nutrients from the body are used to make chemical signals, but they must first cross the "blood-brain barrier." Below: The nutrient choline is transported through the barrier within each capillary by an "assembly line" of proteins (1). The choline is taken up by the terminals of certain neurons (2) and converted into the neurotransmitter acetylcholine (3). When the neurons fire, acetylcholine is released into the synapse (4), where it may be captured by another cell (5). It may also be converted back into choline (6) and reabsorbed by the original cell (7), or released into the bloodstream (8).

Health-Food Hype

THE use of nutrients to treat brain disease remains experimental and should be done under the supervision of medical researchers, with the approval of the Food and Drug Administration (FDA). But you wouldn't know that from a visit to your local health-food store.

Many such stores promote and sell nutrients, purified from food and mixed with other compounds, as remedies for a host of brain disorders ranging from insomnia to senility. But very few of the purported medical benefits have ever been confirmed in large studies of patients.

The sale of a compound labeled "pure lecithin" at a well-known health-food store in Cambridge, Mass., provides an excellent example. Rows of bottled and canned lecithin—in liquid and powder form—are on prominent display at this store. Nearby is a table strewn with literature where shoppers can pick up a brochure entitled "Phosphatidylcholine Aids in Fight Against Neurological Disorders and Aging." The first paragraph explains that phosphatidylcholine (PC) is an active component of lecithin and "has been shown useful in the treatment of high cholesterol and atherosclerosis, heart disease, liver cirrhosis, and blood clotting disease." The brochure goes on to describe the benefits of PC in treating Alzheimer's disease, a particularly tragic form of senility, and other brain disorders. Bold subheads declare "PC relieves the symptoms of tardive dyskinesia," "Choline improves learning," and "Lecithin versus Parkinson's disease."



We soon found that other neurotransmitters shared this unusual property. For instance, when we fed rats another food constituent, choline, or the larger molecule phosphatidylcholine ("lecithin"), which normally provides most choline in the diet, we found that both the production and release of the neurotransmitter acetylcholine increased. Similarly, giving rats tyrosine, the amino-acid precursor for a family of neurotransmitters known as the catecholamines, also accelerated the formation of these compounds.

However, this effect occurred only under certain conditions, which differed from those necessary for converting tryptophan into serotonin. For example, tyrosine and choline increased the production of their neurotransmitter products only when the neurons involved in their conversion were actively firing. Both precursors had little or no effect on the production of neurotransmitters in less active neurons. In contrast, administering tryptophan never failed to speed up serotonin production. This crucial difference stems from the way specific enzymes convert

The brochure fails to mention that the so-called pure lecithin contains less than 20 percent PC and more than 80 percent glop.

What the brochure fails to mention is that the so-called pure lecithin on sale actually is less than 20 percent PC and more than 80 percent other compounds. So even if the medical benefits of PC are someday confirmed in large-scale patient trials, the people eating the glop sold in this store are consuming nowhere near the amount of concentrated PC considered useful. These consumers are also exposing themselves to other compounds that have not been rigorously tested for toxic side effects and that are very high in calories.

The Lecithin Loophole

The reason health-food stores are legally allowed to sell these mixtures as pure lecithin stems from a federal ruling in 1938. At that time lecithin, which is but one compound in the family of chemicals known as phosphatides, was used only as an emulsifier, in foods like mayonnaise or chocolate, to keep the ingredients from separating. All the chemicals in the phosphatide family share this emulsifying property. So the government agreed to allow any phosphatide to be included for commercial purposes under the umbrella term "pure lecithin."

We now know that PC is the only phosphatide that contains choline and can enhance the production of the neurotransmitter acetylcholine (with possible implications for treating brain disease). But the government's 46-year-old ruling on lecithin remains intact, and health-food stores have fully exploited it.—*Richard Wurtman* □

these amino acids into neurotransmitters.

More recently, we have observed that the supply of some amino acids in brain neurons declines markedly when the neurons that use them as neurotransmitter precursors fire frequently. Indeed, these neurons may completely exhaust their reservoir of these key nutrients after periods of intense activity. Other research has shown that such neurons fire frequently during periods of stress. Perhaps that is why our ability to maintain normal lives while coping with severe crises is limited.

Diet-Conscious Rats

Why should evolution have provided the brain with neurons that vary the release of their transmitters according to nutrient intake? We speculated that perhaps these neurons have some special role in food choice. To test this hypothesis, Dr. Judith Wurtman, my wife and collaborator, allowed rats to choose among various foods having different proportions of carbohydrates and proteins but similar calories and—to human palates at least—similar tastes.

We hypothesized that the proportions of proteins and carbohydrates in what the animals ate for "breakfast" would determine brain serotonin levels at "lunchtime." We also expected that if rats ate a breakfast causing a net increase in serotonin—one rich in carbohydrate and poor in protein—they would tend to choose a lunch with the opposite nutrient composition and neurochemical effect. Of course, laboratory rats don't actually eat breakfast and lunch. Instead, they consume 20 to 25 small meals during 12 hours of darkness and a few nibbles during daylight. Therefore, we gave the animals a small "premeal" of either pure carbohydrates or mixed nutrients. Then, several hours later, we allowed them to choose between two diets containing equal amounts of protein and calories but either 25 percent or 75 percent pure carbohydrate. As anticipated, the composition of the premeal had no effect on the total amount of food consumed during "lunch." But the carbohydrate premeal did cause the animals to choose in favor of protein.

While patients can raise their blood choline levels by eating three-egg omelets three times daily, most people would soon tire of such a diet.

These studies and others performed by Harvey Anderson, now at the University of Toronto, provide evidence that the brain is able to regulate the proportions of carbohydrates and proteins consumed during meals.

The Carbohydrate Cravers

Taking this a step further, we hypothesized that a defect in this efficient regulatory system could cause obesity—at least in the group of people known as carbohydrate cravers. At least half of all obese people in the United States crave and consume large amounts of pure carbohydrates, mostly in the form of snack foods. Studies performed at the M.I.T. Clinical Research Center by Judith Wurtman and Sharon Mark, among others, show that most carbohydrate cravers eat snacks at a regular time of day (between 2 and 4 P.M., for example, or 9 and 11 P.M.), and that they desire nonsweet carbohydrate-rich foods such as pasta and bread as much as sweets. These snacks make up 25 percent or more of the average patient's daily calories, an amount that could fully account for his, or more typically her, obesity.

Why do certain people crave carbohydrates at fixed times of the day? We believe that their "need" stems from a property of their brains—just as it is a property of some people's brains that requires them to sleep eight or nine hours per night while others do just as well on six or seven.

We know that the release of serotonin is a signal to the brain that a carbohydrate-rich meal has been consumed, as such a meal increases brain levels of serotonin's precursor, tryptophan. Perhaps carbohydrate cravers have fewer serotonin-releasing neurons than their non-carbohydrate-craving peers. If so, less serotonin would be released and the brain would not think the body had eaten enough carbohydrates and thus would instruct it to eat more. Another possibility is that carbohydrate cravers have fewer molecules for transporting tryptophan at the blood-brain barrier. If that is true, then changes in blood amino-acid levels after a carbohydrate-rich meal would have only a small effect on tryptophan levels in the brain. Or perhaps a carbohydrate meal is less effective in depressing the amino acids that compete with tryptophan for brain uptake; that could be due to the fact that such people release less insulin or are less responsive to the hormone. Perhaps carbohydrate cravers almost never have carbohydrates in their meals because their thin carbohydrate-eschewing doctors put them on high-protein, low-carbohydrate diets.

In any event, the ability of serotonin-producing neurons to "monitor" food-induced changes in blood plasma is of real use to the body. In addition to helping the brain regulate diet, the release of serotonin makes people feel sleepy and less vigorous. It also tends to have a calming effect. Not surprisingly, consumption of carbohydrates induces all these effects.

Indeed, we begin to suspect that some people sense a connection between what they eat and how sleepy or depressed or anxious they feel. They may then "self-medicate" by choosing foods that produce the desired effect. For instance, some patients suffering from a kind of depression that recurs each fall or winter experience a severe carbohydrate craving during this time. Perhaps this craving reflects a subconscious desire to "treat" the depression, since carbohydrates produce some of the same chemical effects on the brain as antidepressant drugs. Similarly, obese people may eat frequent carbohydrate snacks in a subconscious effort to calm their nerves.

Fooling the Brain

The next logical question to pursue was whether we could develop a treatment for obesity by correcting the defect that causes carbohydrate craving. For instance, would a drug that could "fool" the brain into thinking that carbohydrates had been eaten actually diminish a person's appetite for carbohydrates? The ideal drug would be one that releases serotonin into brain synapses, or that prolongs the time serotonin molecules remain in the synapses. And sure enough, experiments have shown that small doses of d-fenfluramine, a typical serotonin-releasing drug, lead to a major reduction in obese people's intake of carbohydrate snacks. Such doses also lead to a smaller but still significant decrease in the number of carbohydrate calories such people

choose at mealtime.

However, using drugs is probably not a long-term solution to weight loss for most people. Our experiments suggest that carbohydrate cravers can satisfy their cravings by eating very small portions of foods high in carbohydrates. For instance, eating gumdrops or a 250-calorie bagel should satisfy the craving about as well as a 1,000-calorie ice cream sundae.

Diet and Depression

The link between serotonin and appetite is only one example of what appears to be a significant correlation between brain chemicals and human behavior. In fact, some forms of human depression may be related to a deficiency in brain norepinephrine, while others may be due to an inadequate supply of serotonin. That hypothesis is based on the fact that all antidepressant drugs now in use cause some increase in both neurotransmitters.

Since tyrosine can enhance the production of brain norepinephrine, psychiatrists have begun testing the possibility that tyrosine might be effective in treating some depressed patients. Psychiatrist Alan Gelenberg and neurologist John Growdon, both at Massachusetts General Hospital, have reported that depressed patients feel less suicidal and despondent after receiving large doses of tyrosine. This effect, confirmed by other investigators, is now the subject of a large double-blind study involving 120 patients.

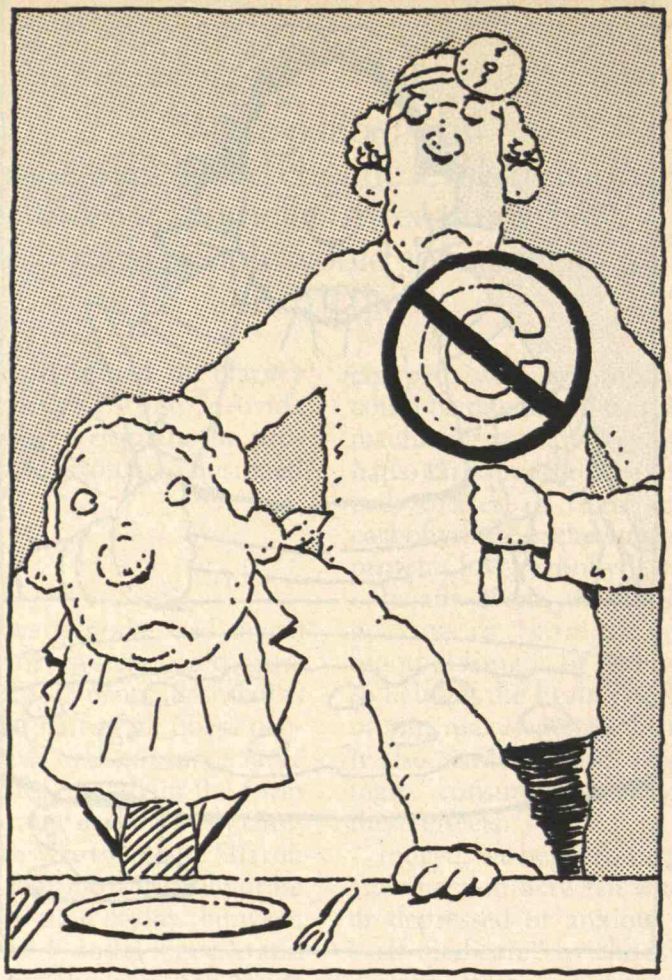
Tyrosine also seems to generate feelings of vigor in people age 40 and older. Furthermore, when tyrosine is given to rats undergoing severe stress, the animals behave normally for a longer time than severely stressed rats who have not been treated. Tyrosine may accomplish this effect by sustaining the production of norepinephrine in the animals' brains. It will be interesting to see whether supplemental tyrosine also has an "antistress" effect in people.

Treating Senility

While there are many possible therapeutic uses for the nutrients that yield brain chemicals, the one that has attracted the most interest is the use of choline to treat Alzheimer's disease, the most common cause of senility. Alzheimer's disease can first manifest itself as minor incidents of forgetfulness in people as young as 45. However, the disease eventually destroys memory and intellect. Alzheimer's disease strikes about 5 percent of Americans by age 65. The disease seems to be associated with damage to the neurons that release acetylcholine into the parts of the brain linked with memory (the hippocampus) and cognition (the cerebral cortices). This damage, which results in a deficiency of acetylcholine, has been observed during autopsy in virtually all patients who suffered the ailment. About one-third of these patients also suffered impairments in other groups of neurons.

Scientists have yet to understand how the neurons implicated in Alzheimer's disease are damaged. But many hypotheses are now being investigated, including one developed at M.I.T. that centers on the concept of neuronal "autocannibalism." Through in vitro experiments with slices of rat brain, Krzysztof Blusztajn, Jean-Claude Maire, and I have found that when there is not enough choline to synthesize acetylcholine, these neurons obtain more of the precursor by chewing up their own cellular membranes, which are rich in lecithin. If such destruction continues over a long period of time, it could sorely damage the viability of these neurons.

But why would there be an inadequate supply of choline in the first place? Perhaps the system that



transports choline across the blood-brain barrier is defective, or the neuron's ability to trap choline molecules is impaired. Once the disease process begins, the surviving neurons might begin firing so frequently—to compensate for the neurons destroyed by the disease—that their choline requirements would become abnormally great, leading to secondary autocannibalism.

Memory Loss and Milkshakes

Despite uncertainty over the fundamental cause of Alzheimer's disease, many scientists are exploring ways to treat victims with drugs that raise brain acetylcholine levels, or that mimic the effects of this neurotransmitter on nerve cells. One way to increase the production of brain acetylcholine—at least in the laboratory rat—is to administer choline or the molecule phosphatidylcholine, known as lecithin. While patients can raise their blood (and brain) choline levels by eating three-egg omelets three times daily (eggs are rich in lecithin), most people would soon tire of such a diet. Besides, nine eggs per day would also provide more than a sensible intake of fat.

So scientists have taken to administering phosphatidylcholine, usually purified from soya beans and mixed in a frappe, or, more recently, available in prepackaged mixes of chicken soup. Although large doses of choline (and tyrosine) are often administered in such experiments, there seem to be few side effects in patients. This may be because choline and tyrosine enhance production of neurotransmitter only in neurons that are actively firing.

Initially, investigators interested in the effect of choline on Alzheimer's disease based their studies on the way dopa, an amino acid not normally found in the diet, was used to treat Parkinson's disease. Thus, they gave patients doses of choline only for days or weeks. A few of these studies yielded transient improvements in some patients; most yielded no useful results at all. More recently, scientists have begun giving patients phosphatidylcholine for six months or more with better results.

In one double-blind study, directed by Raymond Levy, a professor of psychiatry at the Maudsley Hospital in London, 51 patients with Alzheimer's disease received 25 grams of 95 percent pure phosphatidylcholine or its placebo (a cherry-flavored frappe containing margarine) daily for six months. The patients were tested monthly for changes in their memory and cognitive functions, and all were followed for another six months after treatment. Paradoxically, the patients who complied well with the requirements of the study—drinking all of the lecithin frappe and exhibiting large increases in plasma choline levels—failed to show consistent improvement in intellectual function or their ability to care for themselves. But patients who complied less well—only doubling their plasma choline levels—improved throughout the treatment period.

Perhaps too much choline is not good; perhaps the patients who responded had a disease involving only neurons that convert choline into acetylcholine, while the nonresponders also suffered deficits in other types of neurons. Perhaps the people who were less sick to start with remembered each day how badly the lecithin frappe had tasted on the previous day, and decided, on occasion, not to drink it. Only further studies will tell whether the apparent therapeutic effect in some patients is real and confirmable and important. If so, it will constitute the first treatment to significantly benefit patients with Alzheimer's disease.

Perhaps these cravers almost never eat carbohydrates at mealtime because their thin, carbohydrate-eschewing doctors don't allow them to.

We should remember that for the first seven years that physicians attempted to use dopa to treat Parkinson's disease—now a universally accepted treatment—almost every description of its effects was negative. It took an investigative genius—Dr. George Cotzias of Brookhaven National Laboratory—to devise a way to exploit dopa's useful effects. However, we should also remember that many proposed treatments appear to work when first tested on small groups of patients, but then lose their apparent efficacy with larger patient samples.

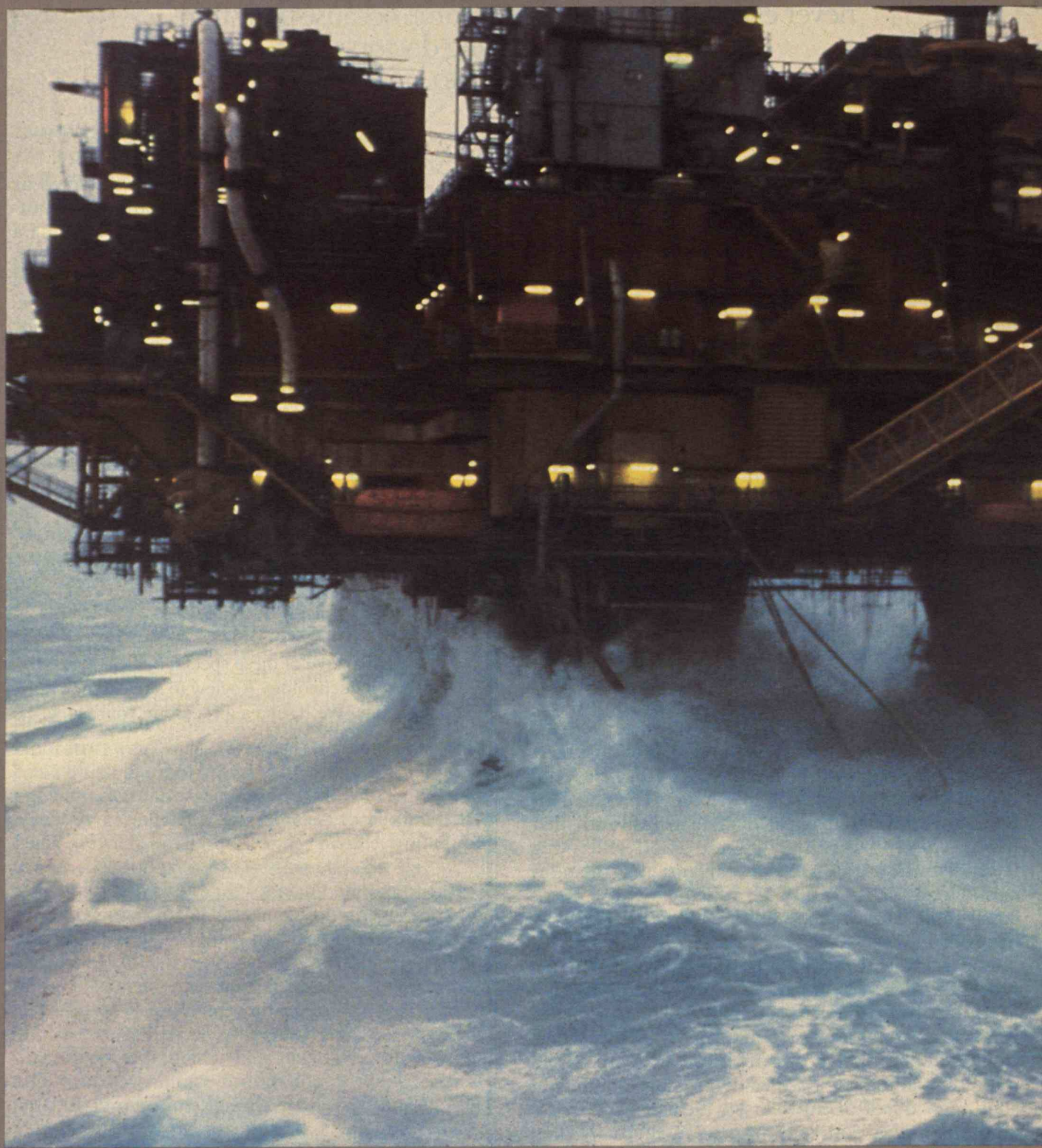
Other scientists have found that administering choline helps curb the facial tics that afflict patients suffering from another neurological disease, tardive dyskinesia. This disease often occurs in patients treated with antidepressant or antischizophrenic drugs for a long time. Some scientists have also found lecithin beneficial in controlling mania, the side of manic-depression that produces hyperactivity and feelings of extreme elation. But all these results still require large-scale confirmation.

Now that pure, palatable lecithin is available in chicken-soup mixes to physicians with government approval, such large-scale studies can finally be performed. But even if results are positive, thorny regulatory issues must be resolved before such nutrients can be widely used to treat disease. For instance, should these nutrients be classified as drugs, as food, or in a distinct category all their own? The nutrients are now considered experimental drugs, and their use is closely supervised by the Food and Drug Administration (FDA). But categorizing them as commercial drugs would be difficult because nutrients simply cannot be tested for safety the same way drugs are.

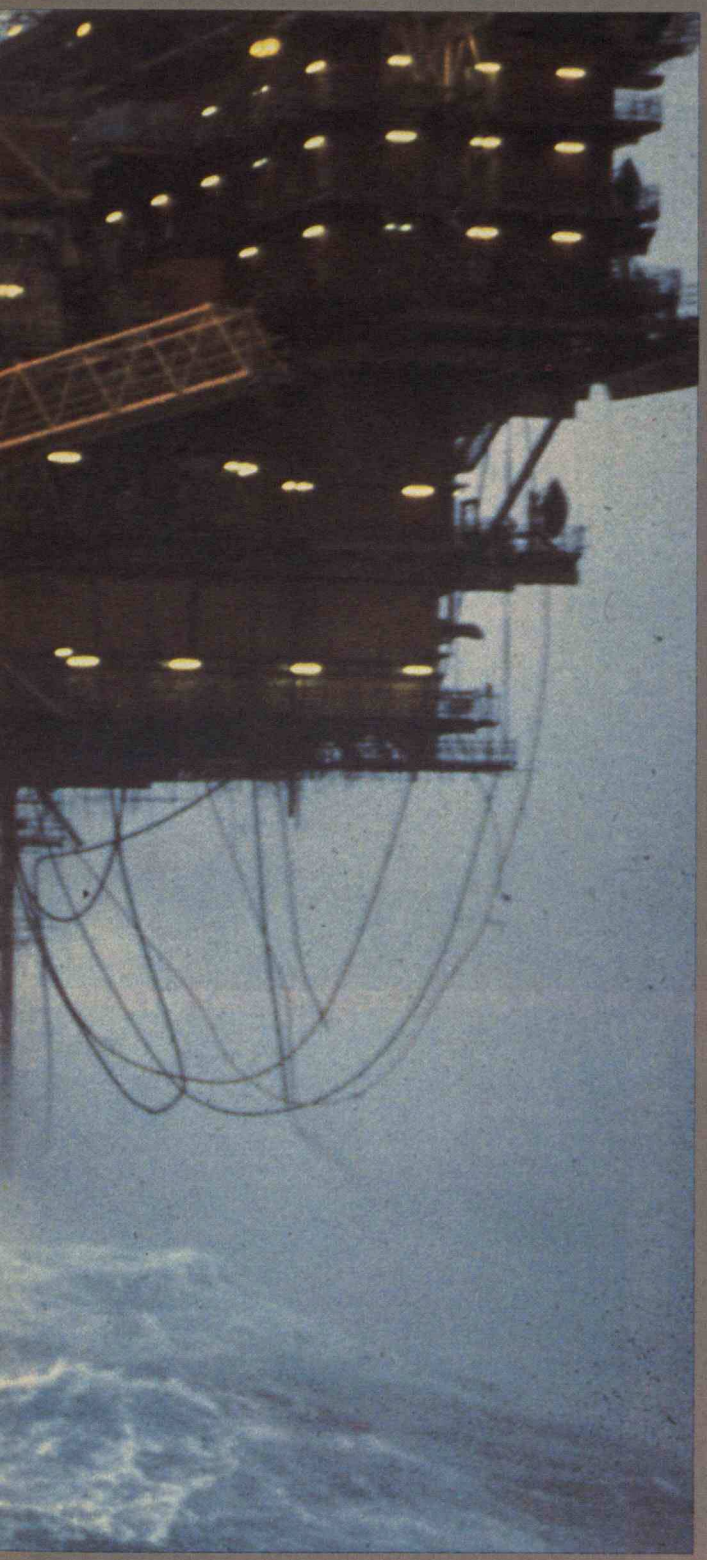
For example, to win FDA approval for marketing a drug, a pharmaceutical company must show that a dosage 100 times greater than the one proposed is not toxic to laboratory animals. While researchers can give such high doses of drugs, which come in milligram amounts, they can't possibly administer such high doses of nutrients, which come in gram amounts and are already present in the daily diet. For example, an animal (or human) would have to eat 800 to 1,000 eggs per day to consume 100 times more lecithin than normally found in the diet. The body simply cannot accommodate that high a dosage—either in food or purified form.

Nor can these nutrients be properly classified as food, since they are not designed to affect only nutrition and taste. The FDA is considering creating a distinct category for these nutrient-drugs. However, there will probably be little impetus for action until scientists are certain that nutrients such as tyrosine, tryptophan, and lecithin can indeed modify behavior and ameliorate disease.

RICHARD J. WURTMAN, M.D. is professor of neuroendocrine regulation at M.I.T.



This production platform in the North Sea stands fast against 100-mile-per-hour winds and 70-foot waves.



Offshore Engineering: Oil from Troubled Waters

Lured by the promise of vast undersea riches, oil companies increasingly look offshore for major new supplies. The quest is moving ever-more-daring oil rigs into deeper and rougher water.

BY HENRY PETROSKI

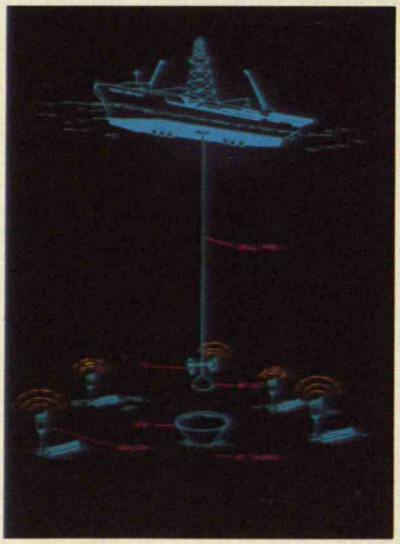
THE *Alexander L. Kielland* was 10,000 tons of steel welded into a five-footed monster of an oil rig capable of virtually walking on water. The ungainly vessel, known as a semisubmersible, was supposed to move from place to place in the ocean, stopping here and there to straddle geologically likely spots and drill exploratory wells. In places where the *Kielland* struck it rich, a permanent production platform would be erected, as if a monument to the peripatetic rig's success.

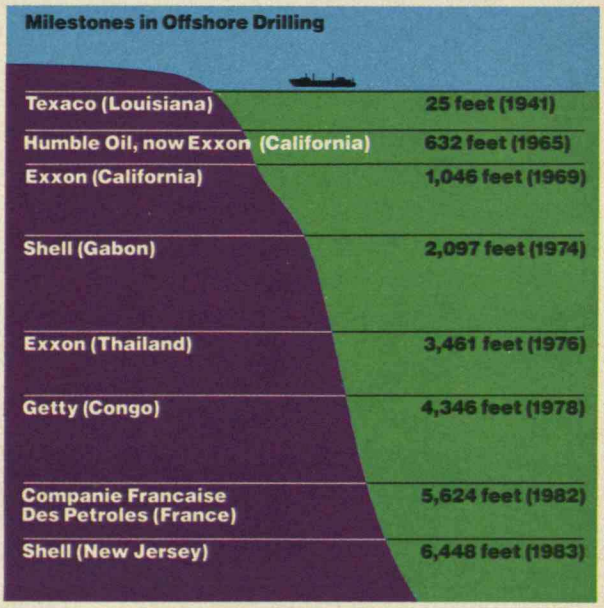
Such potential glory was never to be realized, however. In the fast-moving currents of ocean engineering, the *Kielland* was considered obsolete by the time it was completed

PHOTOGRAPH: NICK SMYTH, SHELL OIL

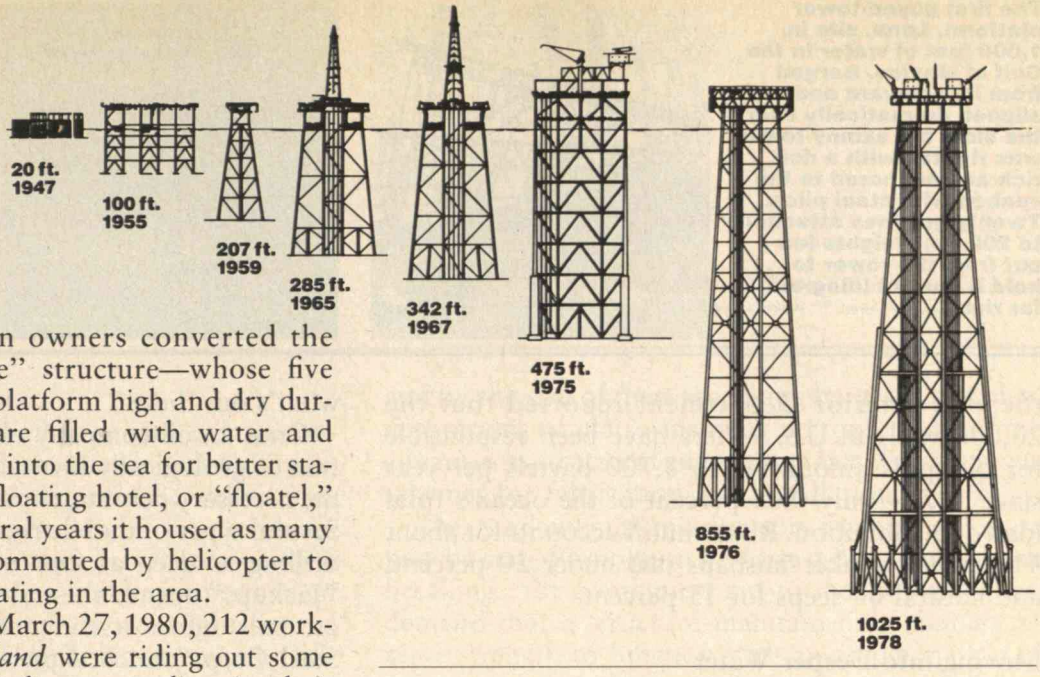
"Jackups" are the most common drilling rigs for exploration (top). They work in depths up to about 500 feet by lowering their legs to the seabed. Semisubmersibles can drill in several thousand feet of water, held stable by flooding their huge pontoons (bottom, left).

But drillships are the champions. The *Discoverer Seven Seas* recently sank a well for Shell Oil in 6,448 feet of water beyond the continental shelf off New Jersey (see chart and diagram). The ship stayed over the wellhead by monitoring sound waves from beacons on the bottom and turning on and off its propellors and lateral thrusters.





PHOTOS: AMERICAN PETROLEUM INSTITUTE; SONAT OFFSHORE DRILLING; DIAGRAM: OMNIGRAPHICS



Oil companies sank "offshore" wells early this century on piers extending from land. But the first production platform in open water away from land came in 1947, in 20 feet of water in the Gulf of Mexico. The record platform now stands 1,025 feet deep off Louisiana — and the industry has even grander plans.

in 1976. Its Norwegian owners converted the French-built "pentagone" structure—whose five large pontoons keep the platform high and dry during transportation but are filled with water and "semisubmersed" 70 feet into the sea for better stability at anchor—into a floating hotel, or "floatel," in the North Sea. For several years it housed as many as 348 workers, who commuted by helicopter to more advanced rigs operating in the area.

In the early evening of March 27, 1980, 212 workers at home on the *Kielland* were riding out some poor weather by eating dinner, reading in their rooms, or relaxing in the sauna or the cinema. Though perhaps made a bit uncomfortable by the rough seas, the occupants were probably not overly concerned for their safety. The North Sea had seen a lot worse than the 40°F temperature, 40 mile-per-hour winds, and 25-foot waves prevailing in the Ekofisk oil field. Indeed, the *Kielland* was designed for much more severe conditions—conditions that might be expected only once every hundred years. And even if it should suffer the calamity of having one of its five legs break away, the structure was supposed to react by listing slowly, giving the workers time to get into life jackets and board lifeboats.

Unfortunately, when one leg did break off—with "an almighty crack," as one worker remembers—the platform began to quiver and the rig tilted steeply. The wind caught the tilting deck, pushing the rig over much faster than expected. The lifeboats, some of which had overturned and become tangled in their cables, could not be deployed according to plan. In the offshore oil industry's worst accident ever, 123 workers died.

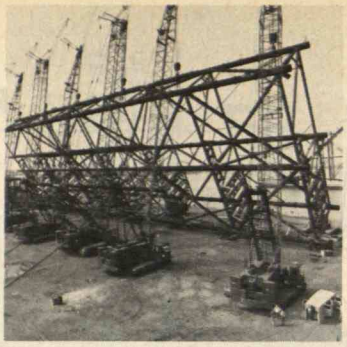
Speculation abounded about what caused the *Kielland*'s leg to break away, ranging from basic design flaws to a collision with a nearby production platform or even a submarine. Design problems seemed unlikely, however, since the *Kielland* was among the newest of about a dozen similar rigs, and fundamental flaws should have shown up in the oldest platforms first. For the final analysis, the separated leg was towed to a calm fjord near Stavanger, Norway. Investigators found that one of the broken braces showed the telltale signs of metal fatigue and the slow but steady growth of a large crack that had gone undetected.

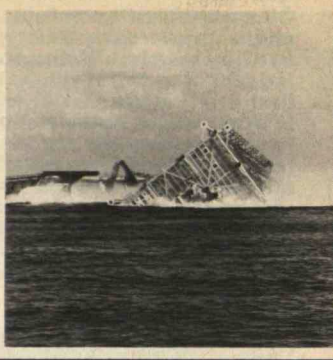
Metal fatigue is the bane of designers. When subjected to millions of cycles of loading and unloading, metal can develop small cracks that continue to grow as long as the load cycles. In an offshore structure such as the *Kielland*, the impact of each wave might extend a crack less than a millionth of an inch—but the sea batters the structure millions of times each year. Of course, structures can function with fatigue cracks as long as they do not become so big that the metal lets go suddenly, the way a piece of wood does under an advancing saw cut. The usual way to cope with metal fatigue is to eliminate all but the most minute cracks from new engineering structures, inspect the structure regularly to determine whether any cracks are growing, and remove the structure from service before the cracks grow to dangerous proportions.

However, the investigators determined that the *Kielland* was flawed from the start. Before the rig was even launched, it must have had a crack almost three inches long in a weld where an instrument bracket was attached to the ill-fated leg brace. The investigators were tipped off by the fact that three inches of the broken crack surfaces were covered with paint, which could only have been sprayed into the crevice when the final touches were being put on the new rig. The rest of the fracture surfaces showed the characteristic growth of the fatigue crack up to the point where the metal finally broke apart, no longer able to hold together with such a severe flaw.

Despite tragedies such as the *Alexander L. Kielland*, the offshore oil industry has a remarkably good safety record. Although the cost of mishaps between 1955 and 1983 totaled about $750 million, that is less than the R&D cost of many advanced platforms being contemplated today. The industry's environmental record has also been noteworthy. Last year

The first guyed-tower platform, Lena, sits in 1,000 feet of water in the Gulf of Mexico. Barged from its shipyard and slipped dramatically over the side, the skinny tower was righted with a derrick and anchored to the seabed with steel piles. Twenty guylines attached to 200-ton weights fan out from the tower to hold it upright (diagram, far right).





the U.S. Interior Department reported that the 20,000 wells in U.S. waters have been responsible for oil spills amounting to 5,700 barrels per year since 1971—only 0.05 percent of the ocean's total load of oil pollution. River runoff accounts for about 41 percent, tanker mishaps just under 20 percent, and natural oil seeps for 15 percent.

Moving into Deeper Water

Still, engineers are striving to design new drilling rigs and production platforms that are even more reliable and at the same time less expensive. This challenge is heightened as the oil industry looks to the ocean for major new supplies, especially to deeper waters and hostile Arctic regions. Offshore wells accounted for roughly 12 percent of domestic production of crude oil in 1983. But the U.S. Geological Survey estimates that 34 percent of the nation's future oil discoveries will be made offshore, and some industry estimates run even higher. At an average cost of about $450 per foot, offshore drilling is four or five times as expensive as land-based operations, but the promise of large undersea fields makes the quest cost-effective.

After a boom in the 1970s, the offshore oil industry suffered through a severe slump. Even now, only about 75 to 80 percent of the more than 700 available drilling rigs are operating, and equipment that once leased for $50,000 a day rests in quiet bays. However, because the fraction of rigs idle seems to have bottomed out last summer, many experts are predicting a turnaround this year or next. For example, researchers at the University of Houston note that U.S. oil use in each of the last seven months of 1983 surpassed 1982 levels, reversing a slide that began in 1978. And they expect continued improvement in the general economy to bolster consumption during 1984, "easing the downward pressure on oil prices." Conoco's vice-chairman, W.P. Schmoe, predicted a resurgence in oil exploration in *Offshore: The Journal of Ocean Business*. He cited as evidence the more than $8 billion that companies paid the U.S. government in 1983 for offshore leases. "With this kind of money tied up in leases," he said, "you can bet companies are anxious to determine what's out there."

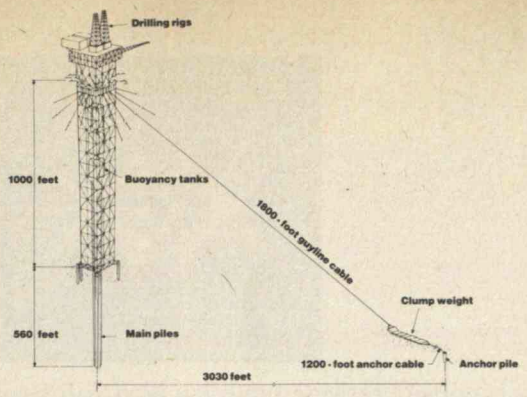
Once an oil company obtains the lease for a section of geologically favorable offshore property and the necessary permits, exploratory drilling can begin. Several types of mobile rigs are available, capable of drilling as deep as four miles beneath the seabed. "Jackups" opened the era of mobile exploration and are still the most common type of rig. Bethlehem Steel Corp. launched the first jackup in 1954. The rig was christened *Mr. Gus* in honor of its owner, the late C.G. "Gus" Glasscock, a one-time high-wire acrobat and wildcatter who had a drilling contract with Shell Oil Co. The 4,000-ton unit sank its first shaft in 40 feet of water off the coast of Galveston, Tex. Company officials predicted that 100 such units would be needed to meet industry demand within 25 years. Today, 30 years later, more than 300 jackups are in use.

Jackups are either towed or self-propelled to drill sites in waters up to about 500 feet deep. The rigs have tall steel legs that are lowered to the seafloor; the drilling platform is then "jacked up" on the legs to a safe height above storm-driven waves. When the job is complete, the legs are again raised high into the air and the platform is ready to float to its next assignment.

Semisubmersibles such as the *Alexander L. Kielland* are the next most common type of exploratory rig. Suitable for waters deeper than jackups can handle, they are moored to the seabed with steel cables or kept relatively stationary by powerful thrusting engines controlled by computers. Wells have been drilled from semisubmersibles in water depths exceeding 3,500 feet.

However, the deep-water drilling champions are the drillships and barges. In January, for example, the *Discoverer Seven Seas* set a world record by completing a well for Shell Oil in 6,448 feet of water beyond the continental shelf off Cape May, N.J. The drillship used a computer that monitored sound waves from beacons on the seabed to maintain its position over the wellhead, staying within a 150-foot radius by turning on or off its two propellors and six lateral thrusters. Although this well proved dry, it was drilled in water more than six times as deep as any wells now producing oil—striking it rich

PHOTOS: BROWN & ROOT



for the technology involved.

Once an exploratory well taps into a large undersea oil field, important cost-benefit decisions must be made. If the oil company expects the well to produce for two or three decades, and if the petroleum can be sold for more than the cost of recovering it and getting it to market, then building a permanent production platform—much more sophisticated than any exploratory rig—might be warranted. Otherwise, the company will leave the field unexploited until oil prices rise or shortages occur. The engineering problems of designing, building, and operating permanent platforms in the uncooperative ocean environment are inextricably tied to this economic analysis.

Underwater Skyscrapers

Production platforms, which only a quarter-century ago numbered about 40 and stood in water no deeper than 100 feet in the Gulf of Mexico, now stand taller than the Empire State Building and number in the thousands. The heaviest rival the ancient pyramids in the ingenuity required to erect them in a sea that shifts much more than desert sands. Yet offshore platforms have grown so quickly in size and complexity that a new generation is often on the drawing board before its predecessors have been fabricated, installed, and proven. Such leapfrogging of designs requires imaginative engineering and entails enormous risks that go with the development of any new technology.

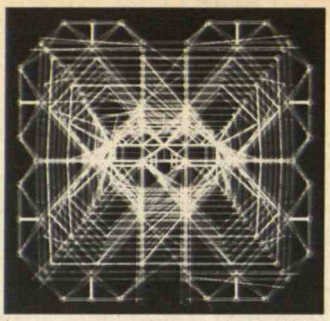
Designing production platforms is a challenge not only because of the hostile environment they must endure for 30 or so years, but also because erecting a structure in hundreds of feet of water is completely different from building a skyscraper on the bedrock of Manhattan Island. There, concrete can be poured from a mixer into stationary forms, or steel beams and columns can be trucked in to be bolted or welded together at the enclosed construction site. No such convenience exists in ocean construction. The huge structures must be built in shipyards and transferred to the oil fields, sometimes on month-long journeys over the high seas. State-of-the-art platforms are already limited by the capacity of shipyard equipment and by the size of their launching barges. Thus, new generations of platforms must not only incorporate advances in structural engineering but also ingenious schemes for fabrication and installation.

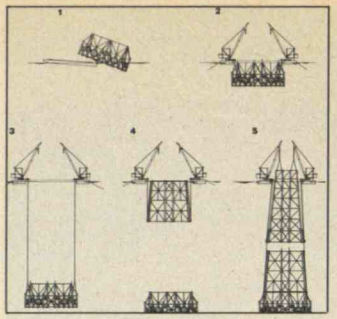
The fundamental requirement for any structure may be stated simply: to perform a function without breaking. Yet economics, not to mention elegance, demand that a structure maintain only enough reserve strength to function with an ample margin of safety, and to hold up under the worst conditions that can be reasonably imagined. A tall building, for example, should be able to withstand the heaviest winds against its facade and the strongest earthquake at its foundation. An offshore platform must also withstand earthquakes at its base and winds against the deck, which may reach the equivalent of ten stories above the sea surface. But more than anything, the structure must withstand the forces of the water, remaining steady enough for hundreds to live and work while bringing perhaps 50,000 barrels of oil to the surface each day. Such goals can never be guaranteed, of course, but careful design can minimize the risks.

Designers must begin with an understanding of the completed structure's functions. Some platforms need only support the machinery used to pump oil out of the underground reservoir and through pipelines that convey the oil to shore. However, while such pipelines do run for 280 miles beneath the North Sea from one well to Scotland, they are not always feasible. The seabed might be too rough or unstable, or the cost of installing a pipeline might be prohibitive. In that case, the platforms must incorporate facilities for storing perhaps a week's production of oil for pickup by tanker.

Deciding how many holes are to issue from the platform also helps determine its size. Efficient oil recovery generally requires multiple well holes that spread through the seabed in all directions from the platform's base, reaching out into the oil field like the curving tentacles of an undersea creature. Other holes may also be required to pump water into the well to push the oil out. The nature of the seabed itself affects platform design as well, since soft, sandy bottoms require different foundations than hard, rocky ones.

DIAGRAM: EXXON





From such considerations have evolved the two dominant designs for permanent production platforms. The most common, called a "jacket," is made of steel pipes welded together and resembles an oversized oil derrick or the superstructure of Chicago's 100-story John Hancock building. Jackets weigh up to 60,000 tons—about the same amount of steel is used to support the Empire State Building—and are fabricated in one of many large shipyards worldwide. A jacket is floated to its installation site horizontally, on a barge or supported by the buoyancy of its own hollow legs. It is then righted into position, often within six inches of a predetermined location, using barge-mounted derricks or by filling the hollow legs with water. Finally, piles to anchor the platform are driven into the seafloor through preattached sleeves or through the jacket legs themselves.

The Cognac platform now holds the deep-water record: 1,025 feet. Manufactured by Brown & Root for Shell Oil, the platform stands 1,265 feet tall in the Gulf of Mexico. The jacket was made in three pieces, which were transported separately from the shipyard at Morgan City, La., to a site about 15 miles from the mouth of the Mississippi River. Two computer-controlled derrick barges first lowered the base to the seafloor, where it was secured with seven-foot-diameter steel piles embedded about 450 feet. Such deep piles are often necessary in the Mississippi Delta to keep platforms from moving with the shifting alluvial deposits. The barges then stacked the other two sections onto the base, and the platform itself was installed—in all, a superb demonstration of marine construction. Indeed, the American Society of Civil Engineers named Cognac the "Outstanding Civil Engineering Achievement of 1980."

While its floor may be more stable, the North Sea is not as calm as the Gulf of Mexico, so feats of precision such as the installation of Cognac are impossible. Thus, concrete-gravity platforms have become popular for quick, one-piece, pile-free installations in hostile waters. Chevron Petroleum's Ninian platform is the largest at 600,000 tons, ten times heavier than Cognac's steel jacket. Concrete-gravity platforms are built in deep-water shipyards, such as those in the Scandanavian fjords. Construction takes place behind a dike, and the site is flooded when the job is complete. Despite the platform's great weight, its hollow legs provide enough buoyancy to make it float. The platform is then towed upright to its destination, often towering 500 feet above the waves. The legs are ballasted with water or rock and the platform sinks to the bottom, where its sheer weight holds the platform stationary.

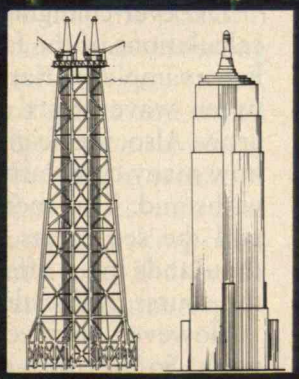
The Siren Sea

Protecting permanent production platforms against 100-foot waves generated by once-in-a-century storms may appear to be the $64,000-question that engineers must answer. However, they know that the sea can also nickel-and-dime a platform to destruction. In fact, the relentless slapping and passing of millions of ordinary waves can account for 95 percent of the forces on a platform's substructure, and can shake a structure to pieces as surely as a soprano's voice can shatter a wine glass. Resonance, a phenomenon of physics, is the culprit. A glass, like any object of nature or engineering, will vibrate in a characteristic way at certain frequencies when excited. If the exciting frequency—say that of the soprano's high note—matches the glass's natural resonant frequency, then force and object can be in synchrony and each pulse of air pushes the glass closer to its breaking point.

The frequency at which an offshore platform vibrates when excited is largely determined by its mass and stiffness, and by the way it is connected to the ocean floor. Almost all fixed offshore platforms have similar natural frequencies because their construction materials have similar physical properties. These frequencies range from one cycle every ten seconds to ten cycles every one second—or 0.1 to 10 Hertz. Since the ocean's surface moves with frequencies ranging from about one wave per minute to one wave per second—about 0.02 to 1 Hertz—clearly the platform may sit like a fragile piece of crystal stemware in the siren sea.

Since the frequency of the ocean's waves can hardly be controlled, engineers must design offshore structures to avoid resonance above all. They start by determining the natural frequencies of a proposed design, usually by analyzing computer models of the structure. If its frequencies lie within the range of the wave frequencies of the intended ocean location, the engineers can stiffen or soften the structure so that it has a more benign frequency range. If this

PHOTO, DIAGRAMS: SHELL OIL



The world's deepest offshore platform, Cognac stands 1,265 feet tall — 15 feet taller than the Empire State Building. Its "jacket," made of steel pipes welded together, resembles an oversized oil derrick. Opposite page: A computerized structural view as seen from atop the platform (left). Cognac's installation in the Gulf of Mexico was an awesome display of marine engineering (diagram, right).

Tension-leg platforms show promise for depths of 6,000 feet or more. Steel cables connect the floating platform to the seabed, holding it steady against winds and waves while allowing enough movement to prevent damage (right). Conoco is building the first such platform (above), which will soon be towed into the North Sea.

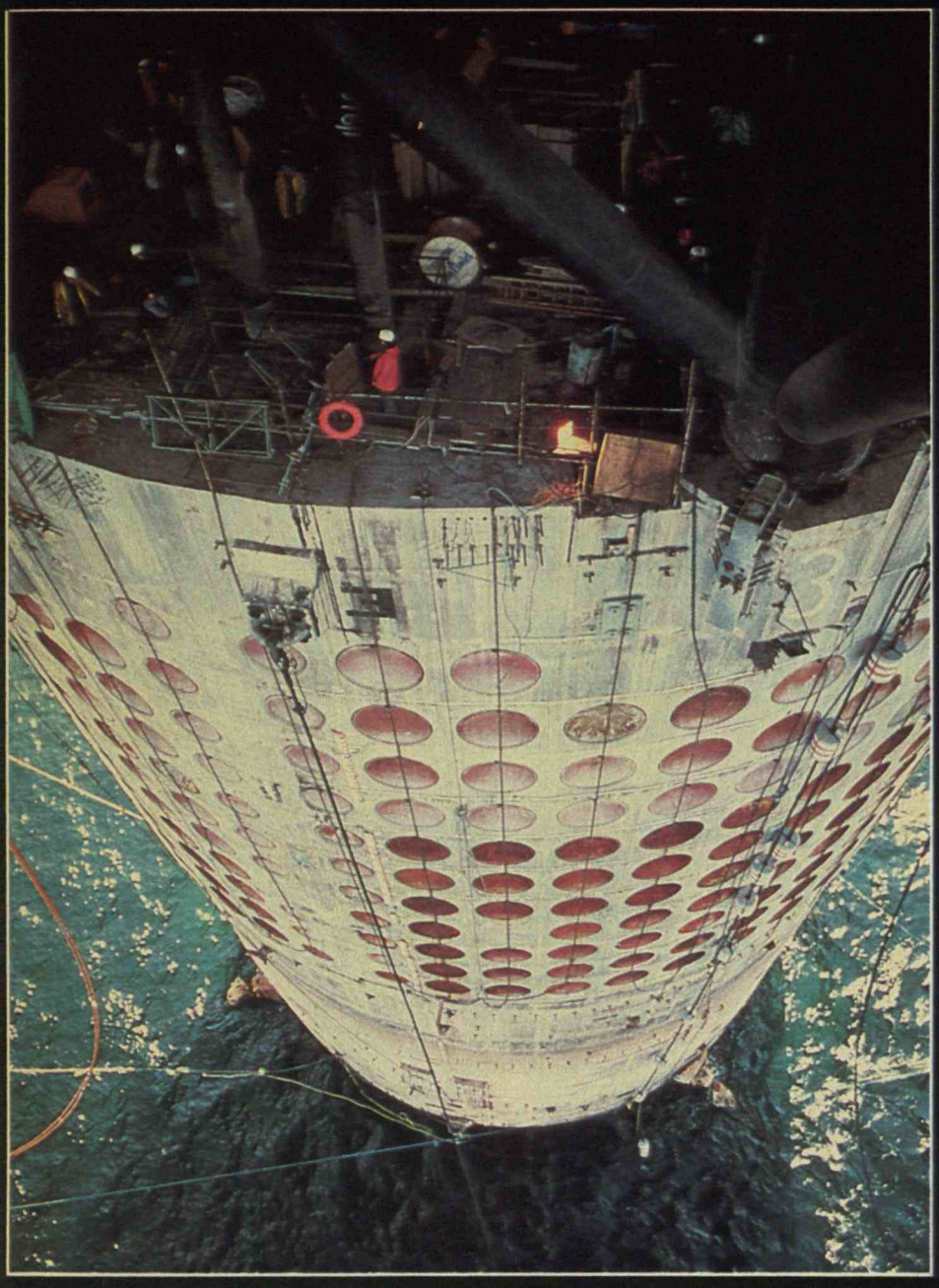
cannot be done economically—by adding, subtracting, or rearranging steel and concrete, or by changing the way the platform is attached to the seabed—then the design must be abandoned.

Ocean waves pose another threat to production platforms: they cause structural fatigue of the kind that did in the *Alexander L. Kielland*. The length of time a platform can endure the repeated pushes and pulls of the ocean is known as the structure's fatigue life, and calculating that life is critical in verifying an offshore design. Even towing a new jacket out to sea sometimes creates so many cycles of bending, as the barge rides the waves, that this fatigue must be included in estimating the structure's lifespan. For example, engineers calculated that the three-week voyage of the Vuxhall platform from Morgan City, La., to Stord, Norway, consumed 10 percent of the structure's fatigue life.

The ever-changing nature of the sea complicates calculations of the fatigue life of offshore structures. For example, variations in the amount of time between wave crests affect the rate at which cracks grow. Also, the height of the waves greatly influences how many cumulative loading cycles a structure can withstand. This means that the amount of push or pull the sea exerts on any given joint among the thousands in an offshore platform, at any time over the course of decades, is anyone's guess.

However, engineers cannot design on pure guesswork. So they turn to a "stochastic," or probabilis-

PHOTOS: CONOCO



Massive concrete-gravity platforms are popular in hostile waters, as their weight holds them securely on the seabed. Chevron's Ninian platform, at 600,000 tons, is the largest. It towered some 500 feet above the waves when towed into the North Sea (left and top). Above, workers test safety capsules for use if they need to evacuate.

tic, approach for calculating fatigue life that is increasingly employed in all branches of engineering. They use the historical record at a proposed platform site to determine the probability that the platform will experience certain conditions—even including for good measure a hypothetical 100-year storm, perhaps represented by 100-foot waves and winds blowing 100 miles per hour for more than six hours. The goal is to anticipate possible failure scenarios and design a certain amount of forgiveness into proposed structures. This can be done by making parts strong enough to carry the extra load if a major break occurs, or by devising safety measures to protect workers.

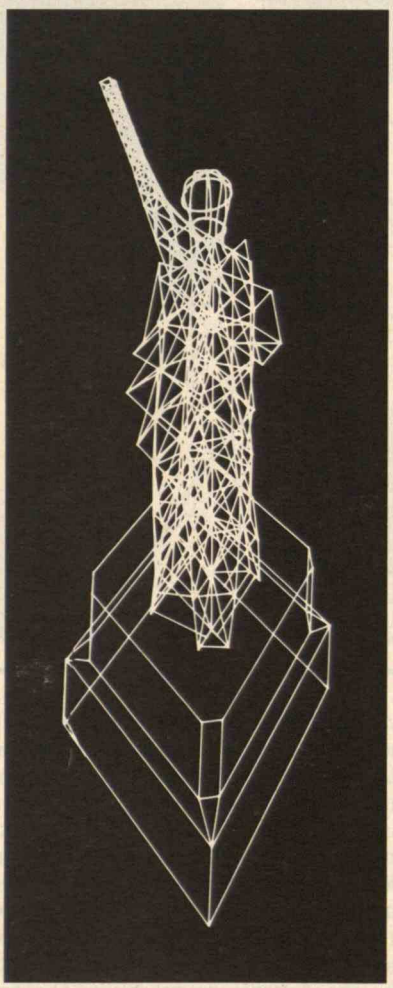
As commercial explorers find vast oil fields in deeper and more hostile waters, conventional fixed platforms become less and less attractive from both an engineering and economic standpoint. Thus, designers are proposing new concepts that don't rely on "brute force" to resist the ocean's forces—concepts that use less construction material and may therefore be less expensive. For depths up to 2,500 feet or so, the guyed tower looks promising. This tall, slender structure—similar to a television transmission tower—sits on the ocean floor and is anchored with steel piles as usual. A network of symmetrically arranged steel guylines keeps the skinny tower from overturning, allowing the tower to move slightly and then return to its normal po-

Continued on page 76

PHOTOS: CHEVRON PETROLEUM

How to treat a world-renowned lady who has stood majestically through winter storms and shimmering heat, but shows signs of weariness as her one-hundredth birthday draws nigh.

Liberty Under Repair



BY TOM BURROUGHS

She would have been impressive anywhere, standing 151 feet tall, weighing 280 tons, and visible for 42 miles on a clear day. But the Statue of Liberty is more than just a monumental figure. She has welcomed generations of immigrants and visitors to New York harbor and now symbolizes the United States to countless millions of people around the world.

Liberty was a gift from "the people of France," presented to the U.S. minister in Paris amidst great ceremony one-hundred years ago on July 4, 1884. The statue was then dismantled and shipped to her current home on Bedloe's Island off the tip of Manhattan. From afar, Liberty appears much as she did during her formal U.S. debut in 1886. Close up, however, time and the elements have clearly taken their toll. Stains and discolorations mar her copper skin and corrosion afflicts the gigantic iron framework inside the statue.

Several years ago the National Park Service (NPS), owner and operator of the monument, started to worry. NPS preservation specialists examined Liberty closely in 1980, after the statue was occupied by protestors, and were disturbed by the signs of aging and environmental damage they found. The next July, the French-American Committee for the Restoration of the Statue of Liberty—formed to honor once again the friendship between the two nations—began a two-year investigation of the statue.

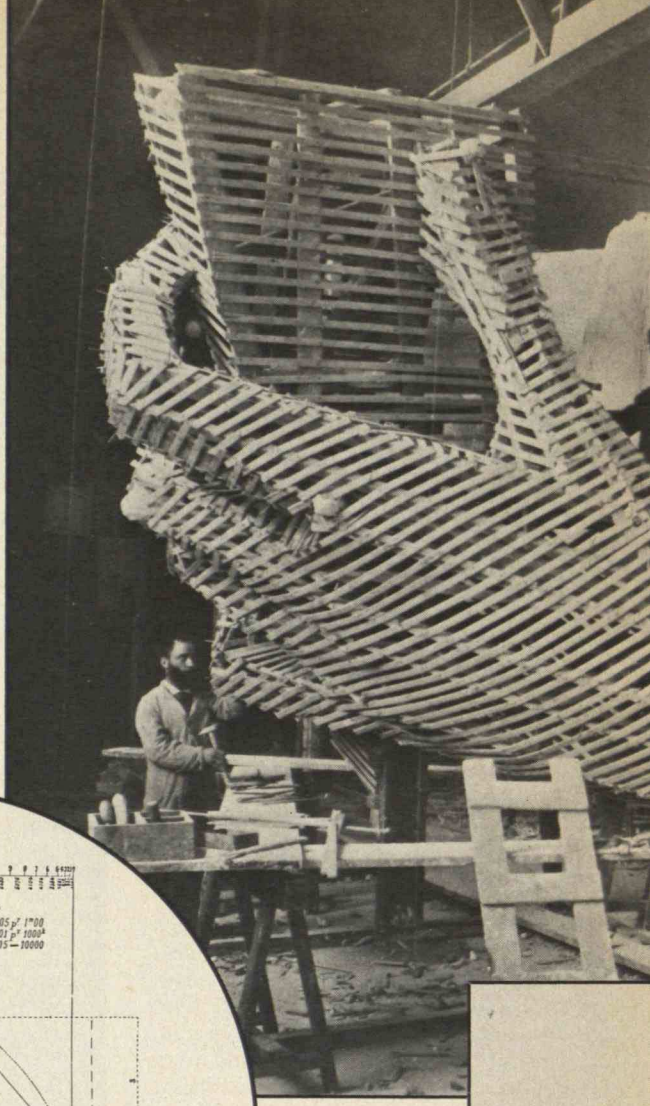
The architects and engineers found 13 problem areas, confirming the worst suspicions. "Major renovation work on the statue's iron framework and copper skin is needed to preserve the monument and to avoid serious problems in the future," says E. Blaine Cliver, chief of historic preservation for the NPS's North Atlantic Region. "Safety isn't a critical issue at present, but could be unless proper repairs are made."

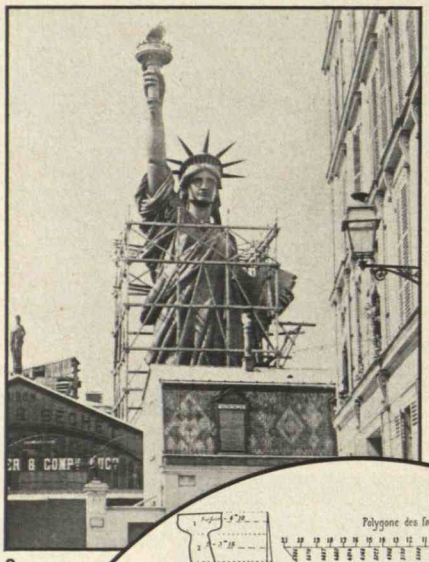
Refurbishment of the great lady is now under way, paid for largely by contributions from people in the United States and France. The $39 million effort will restore the monument's structural integrity and renew her appearance, as well as provide better regulation of the statue's internal environment and improved visitor access and safety. Work is scheduled to be completed by July 4, 1986, in time to celebrate Liberty's one-hundredth anniversary in the United States. She will then be prepared to stand for many more decades, torch held high, looking as her creators intended—"springing from the bosom of the deep, representing Liberty enlightening the World."

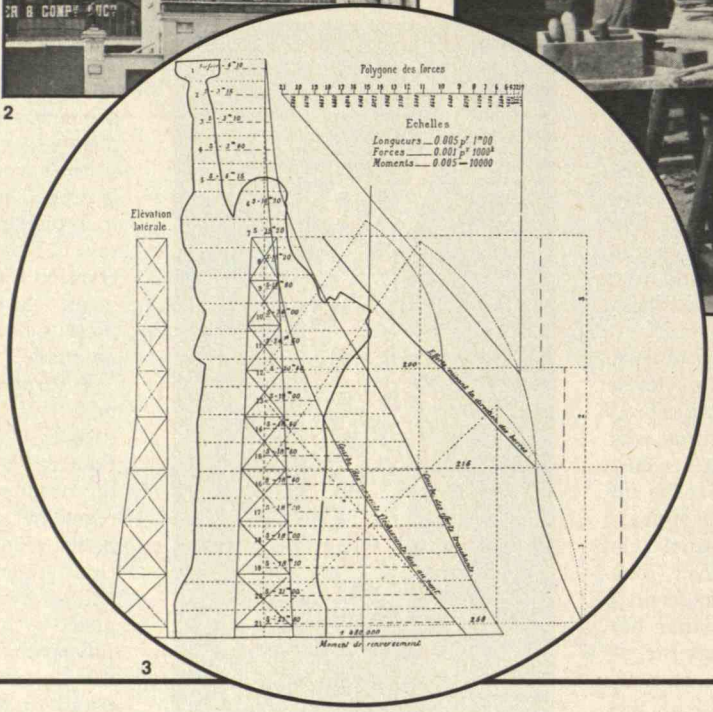
A Statue Is Born

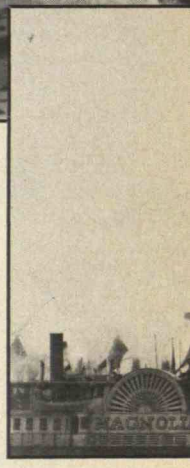
The idea of a monument to liberty was the brainchild of Edouard de Laboulaye, a distinguished historian and legal scholar. He proposed the notion at a dinner in Versailles in 1865, suggesting that the work be ready to commemorate the centennial

PHOTO: ROBERT DEUTSCH, USA TODAY









The Statue of Liberty was born in Paris, designed by the sculptor Frederic Bartholdi (1). Shown working on her left hand, Bartholdi (second from right) used full-scale wood and plaster mockups to shape the 300 thin copper plates that form the statue's skin.

Gustave Eiffel engineered the statue's iron framework (2 and 3)—a considerable achievement, since Liberty, atop her pedestal, became the world's tallest structure. Towering over rooftops during construction, the statue was presented to the U.S. ambassador on July 4, 1884, as a "gift from the people of France." She was then dismantled and shipped to America.

Workers reassembled Liberty on Bedloe's Island in New York harbor (4 and 5). But some of the pieces were deformed in transit, and the workers also deviated from the French plans. Her head is thus two feet out of alignment and her crown pierces her right arm.

Liberty made her formal U.S. debut in 1886 (6), witnessed by more than a million people.

of America's independence. Among the group at dinner was Frederic Auguste Bartholdi, a sculptor who enthusiastically took on the job of designing and building the monument.

Events moved slowly. The French political scene was in turmoil, as monarchists and republicans debated how to restructure the nation's government, and the disastrous Franco-Prussian War also intervened. But in 1871 Bartholdi visited New York and returned with an image of the colossal figure he wished to raise on Bedloe's Island. This initial concept was influenced by the "granite beings" of Egypt that he favored. However, Bartholdi eventually looked closer to home for models—Liberty's facial features are those of his mother, and his wife-to-be inspired the figure.

Construction of the statue was a technological triumph. In 1875 Bartholdi completed a 4-foot clay model, which he scaled up by making progressively larger models in plaster. Each enlargement required more than 9,000 measurements to translate the dimensions precisely. The final model stood 36 feet tall.

Next, Bartholdi and his assistants divided this model into 300 sections and made copies in plaster that were four times larger. These sections were now full-sized, and carpenters constructed massive wooden forms that followed the plaster contours exactly. Craftsmen then hammered Liberty's metal skin into shape against these forms. Bartholdi originally planned to use bronze, but weight problems forced a switch to copper. The 300 thin copper plates would be joined together by some 300,000 copper rivets.

A major engineering challenge remained—figuring out how to support the statue. After all, Liberty, standing on an 89-foot pedestal and 65-foot granite base, would become the tallest structure in the world. Bartholdi eventually called upon Alexandre Gustave Eiffel, a respected en-

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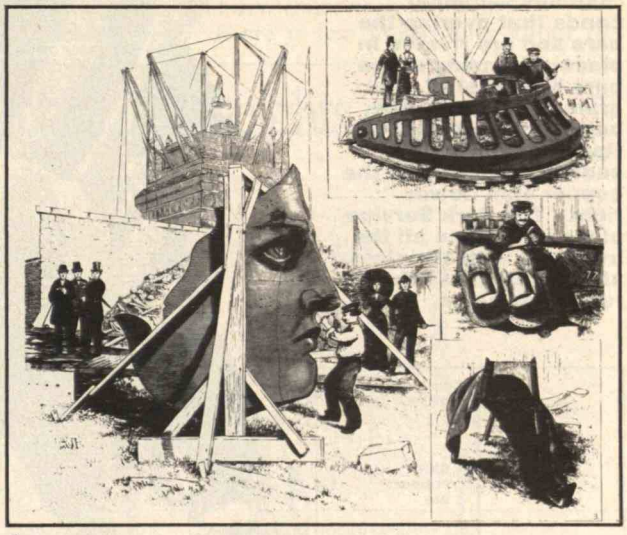

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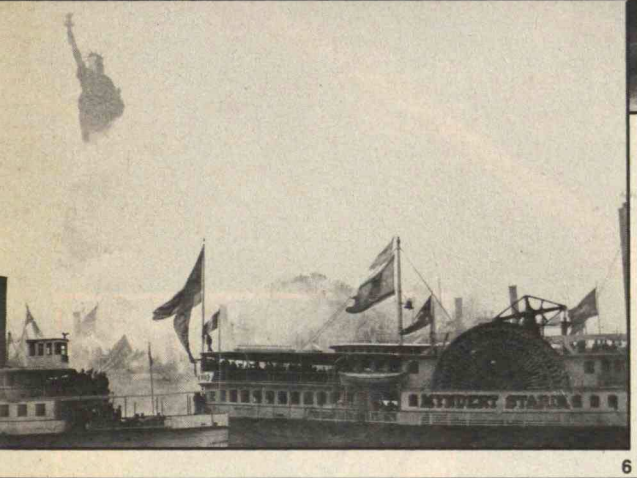

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gineer even then, years before he erected his famous tower on the banks of the Seine. Eiffel devised a central iron pylon, adapted from his bridge designs, to serve as the backbone of the statue. But most remarkable was the iron framework he designed to support Liberty's copper skin. The skin—fragile yet totaling roughly 200,000 pounds—needed support not only against gravity but against the high winds of New York harbor that would buffet her surface, far larger than any sail.

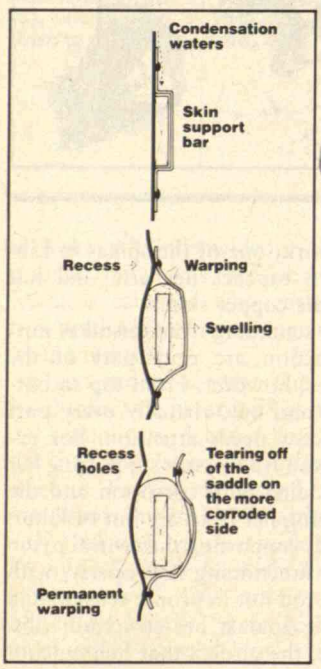
Hundreds of Parisians turned out each Sunday to watch the statue take shape, steadily growing above the nearby rooftops. Then, after Liberty was formally presented to the U.S. minister in 1884, workers reversed the assembly process, packing the 300 pieces of her copper skin in 49 mammoth wooden crates and the iron framework in 36 others. Thus disassembled, Liberty traveled to America by truck, train, and warship. Unfortunately, she arrived somewhat the worse for wear, with some pieces deformed in transit.

Adding insult to injury, U.S. workers reassembling the statue did not match the French rivet holes in every case. Liberty's head was thus installed about 2 feet off Eiffel's original alignment, generating unexpected stresses. The workers also made mistakes in following the plans for the central framework; one of the spikes in Liberty's crown touches her arm and has punctured the copper skin.

Problems stemming from mistakes during construction are only part of the current woes, however. From top to bottom, inside and out, virtually every part of Liberty now needs attention. For example, the iron framework supporting her crown is riddled with corrosion and the arches forming her head are out of kilter. The guy rods supporting the central pylon seem to be functioning improperly, with at least one rod not in proper tension and two pressing against her structural ribs. At the base, the girders that help anchor

Among her many ailments, Liberty suffers a bad right arm. Workers originally built glass inserts into the torch's flame so she could serve as a lighthouse (middle inset). But water has steadily leaked through the flame and run down the arm. The arm is now so corroded that there is risk of structural failure, and its internal framework must be rebuilt. The torch is also in critical condition and will be replaced.

Liberty's biggest problem involves her skin-support system, a network of flat iron bars shaped to fit the interior curves. The bars are linked to the skin with "saddles"—copper bands that overlap the bars and are riveted in place. But many of the bars have rusted (diagram, lower left). The buildup of rust has ripped out about 600 saddles and warped the copper skin (lower right). The Park Service plans to replace all the iron bars with stainless-steel substitutes that resist corrosion.



From top to bottom, inside and out, virtually every part of the statue now needs attention.

the pylon and support the statue's skin are partially corroded. But Liberty's most serious ailments involve her "skin-support system" and right arm.

The iron armature that Eiffel designed to support Liberty's copper skin is formidable. It features a weblike network of flat bars, two inches wide and five-eighths of an inch thick, that are precisely bent and shaped to follow the interior curves closely. The bars are linked to the skin with "saddles"—copper bands that overlap the bars and are riveted in place. The roughly 1,500 saddles were designed so the flat bars could slide freely, allowing the skin to move with the wind and expand or contract with temperature changes. Although the idea was ingenious, the system no longer functions.

Many of the iron bars in the armature have deteriorated over the years. The culprit has been electrolysis, a chemical reaction that can occur when two dissimilar metals—in this case, iron and copper—touch or come close together. A layer of shellac-soaked buffer material was supposed to keep the incompatible metals apart, but the buffer soon wore away. Indeed, NPS officials say a "substantial number" of the bars have lost as much as half of their thickness through electrolysis.

Moreover, many of the bars have seriously rusted. Rain seeping through joints in the skin, as well as condensation of water vapor from the humid air inside the statue, have hastened the damage. In many spots the rust has jammed the space between the bars and their saddles, preventing the bars from sliding properly. But more importantly, the buildup of rust has partially or totally ripped out the rivets anchoring about 600 saddles and permanently warped the copper skin.

The problems afflicting Liberty's right arm stem from an early attempt to make her earn her keep. Congress decided the statue should also serve as a lighthouse, so colored-glass inserts were built into the copper flame of the torch. Unfortunately, the jury-rigged flame was never watertight; moisture steadily leaked into the torch and ran down the inside of the arm. The arm's iron framework is now so severely corroded, especially where the arm connects to the torch, that NPS officials believe there is a definite risk of structural failure.

The torch itself is also in critical condition. For example, the copper crosspieces holding the colored glass in place are badly deteriorated. Ironically, the damage has been exacerbated by iron bolts put through the crosspieces to make them stronger; this mixing of iron and copper only set the stage for destructive electrolysis. The torch has also suffered most from the elements, as it is the most exposed part of the statue, and many of its intricate decorations are worn away.

Diagnoses and Cures

Just as doctors obtain as much information as possible before treating a patient, the architects and engineers responsible for rejuvenating Liberty are bringing to bear a host of instruments and tests to measure her vital signs. They have also built an 8-foot-tall replica of the statue's framework and developed a computer model of the structure. Fed information about the various stresses and loads on the structural components, the model will help researchers determine which joints and members are critical and in need of attention.

The researchers recently got their best chance yet to examine their patient in detail and at close range—not an easy task when she towers more than 300 feet in the air—when workers completed a scaffold around the statue. Just building the scaffold was a major project with its own strict requirements. For example, the scaffold had to be rustproof and surround the statue without touching to allow for Liberty's considerable sway.

One needed diagnosis concerns the extent of damage to the ailing right arm. By removing sections of the copper skin, the researchers should be able to determine how much the arm's structural framework has deteriorated. NPS officials say that every effort will be made to repair the arm in place. But if damage is too extensive, the arm will be removed at the shoulder and new framework installed.

There is less uncertainty about the

torch, as its internal iron structure and flame, and much of the ornamental copperwork, are beyond repair and must be replaced. (Still open, though, is the question of whether the torch must be removed for restoration.) The new version needs to be watertight, and the latest plan calls for the flame to be made of copper gilded with gold. NPS preservationists think this is how Bartholdi originally designed the torch, but the gilding soon wore away. However, there is no plan to reopen the torch's viewing balcony to the public. It was closed in 1916 when an explosion at the Black Tom munitions plant in New Jersey popped about 100 rivets out of the arm. Workers quickly replaced the rivets, but officials decided to keep the torch blocked off because the narrow access by ladder was creating congestion problems.

Liberty's external appearance will be left essentially unchanged. "We will take every step to assure that she remains as majestic and as beautiful as she is today," says NPS director Russell E. Dickerson. Any replacements for the copper skin and rivets will be "prepatinized" to match the familiar bluish-green color. Patina is a protective coating that copper develops naturally, but it can be quickly induced using chemicals. Liberty will then get a detergent bath to remove pollution particles and other foreign materials, and tests are under way to identify the best method for removing rust stains.

Inside the statue, restoration begins with the rather unglamorous chore of stripping paint from the skin and the iron framework. A dozen or so coats have built up since the statue was first painted around the turn of the century, the successive layers reflecting the latest in paint technology. The paints were supposed to retard corrosion, but moisture stealthily penetrated the layers and formed hidden pockets of water, producing corrosion that is merely out of sight.

More than 100 million Americans can trace their ancestry to immigrants whose first view of the nation was Liberty.

Once workers have removed all the paint from the skin—partly by spraying on pressurized liquid nitrogen—the copper will be repaired where necessary and probably treated with an anticorrosion preservative. Researchers will also be better able to judge how much damage the skin has suffered from weathering and pollution. On this score the news may be good; preliminary tests in 1981 indicated that the thickness of the copper has been reduced by only about 10 percent, much less than might be expected for a structure that has spent a century in the middle of New York harbor.

Then comes the biggest job. All the flat iron bars in the skin-support system—more than 1,300 bars totaling 35,000 pounds—must be replaced with stainless-steel substitutes. The NPS selected stainless steel, an iron alloy, because it is practically immune to rusting and corrosion. Stainless steel also remains strong for a long time and has mechanical properties similar to the "puddled iron" used in Liberty's bars. This reflects a guiding principle in historic restoration that says that replacements should be as similar as possible to the originals. According to Garnett Chapin, special assistant to the director of the Park Service, the new bars "will have to be shaped piece by piece on site" to match the twists and bends of the iron counterparts. Workers will replace the armature a section at a time—a tedious process made even slower because only a few crews at a time will be able to work in the cramped quarters.

To help keep Liberty in shape when restoration is complete, she will be fitted with an environmental-control system to regulate temperature and humidity. Not only does the statue's interior become uncomfortable during the summer; the heat and moisture also promote structural deterioration. The steady parade of visitors contributes greatly to such problems, as their breath increases the moisture content of the air and their body heat pushes up the temperature. This was of little concern at the time Liberty was erected, since she was intended to accommodate only occasional visitors. But last year nearly 2 million people toured the statue.

Liberty Island—as Bedloe's Island is now called—will continue to host visitors while the work goes on. Indeed, Russell Dickerson of the NPS sees this as the opportunity of a lifetime. "The Statue of Liberty is, in our view, the greatest artistic colossus of all time," he says. "We hope everyone will come to visit it during this unique period of historic restoration."

TOM BURROUGHS is a senior editor of Technology Review. *Susan E. Schur, who is the founder and editor of* Technology & Conservation *magazine, contributed substantially to the technical content of this article. She holds degrees in metallurgy from M.I.T. and is a member of the Board of Advisers to the M.I.T. Museum.*

All photographs and drawings courtesy of the National Park Service, the Statue of Liberty-Ellis Island Centennial Commission, the French-American Committee for the Restoration of the Statue of Liberty, Bettmann Archive, and the Library of Congress.

Agriculture: Learning from Ecology

Midwestern farms thousands of acres in size frequently produce one crop —a single variety of wheat or corn. To increase the yields of such "monocultures," industrialized agriculture generally alters the environment with fertilizers, pesticides, and irrigation. And plants themselves may soon be altered by recombinant-DNA techniques. But some ecologists are exploring a different approach to improved agriculture. "We look at the environment and choose the combination of plants that will produce the best yield," says John Vandermeer, a specialist in tropical ecology at the University of Michigan.

Specifically, the ancient practice of intercropping—planting two or more crops in the same field, resulting in a "polyculture"—is sometimes proving superior to a monoculture. "Intercropping may increase yields, reduce pests, and control weeds," says Vandermeer. This method may be particularly helpful in developing countries such as in Central America, where farmers cannot afford expensive fertilizers, pesticides, and machinery.

For example, Vandermeer has found that intercropping tomatoes and beans increases yields in climates as diverse as those of Michigan and Costa Rica. When fertilizers are used, tomato-bean polycultures produce tomato yields 50 percent greater and bean yields 20 percent greater than monocultures where the plants are grown separately. Even without fertilizer tomato yields increase 40 percent and bean yields remain the same.

Intercropping corn and beans in Ann Arbor reduced the damage caused by the corn-ear worm and increased crop yield by 50 percent.

Pests may be controlled in a polyculture if they consume only one plant because they have a harder time finding it, says Stephen Risch of the Division of Biological Control at the University of California at Berkeley. In experiments with corn, bean, and squash polycultures in Costa Rica, Risch found fewer beetles than in a monoculture. This was because the beetles did not move as much among plants to establish new colonies. But intercropping may actually make a pest more abundant if it is able to thrive on two or more plants in a polyculture. To use intercropping knowledgeably, says Risch, "we need more case-by-case research."

To be practical, intercropping must be integrated with local farming methods and crop markets. John Houghton of Monsanto Agricultural Products Co. learned this when he was an advisor for a project in Costa Rica that was intercropping oil palms with soybeans. The project was a technical success, producing good yields, Houghton says: "But there was no processing and marketing system down there for soybeans."

Houghton worked on another intercropping system for crops grown and marketed in the Midwestern United States. This system arose from the common practice of "double cropping." Farmers plant winter wheat, harvest it in June, then plant soybeans, and harvest them in autumn. An early frost can kill the soybeans, but if farmers intercrop them between wheat rows early in the spring, they mature before the frost. Houghton predicts that this form of intercropping will become widespread, enabling farmers whose land was previously thought to be too far north to take advantage of double cropping.

Ecology and Machinery

A major problem is that intercropping is sometimes incompatible with mechanization. Brian Shultz of the University of Michigan found that intercropping tomatoes and cucumbers in Michigan and Ohio, where both are grown commercially in monocultures, can increase yields 14 to 32 percent. But over the last 15 years farmers in these areas have switched completely to machine harvesting of tomatoes, and the machines were designed for a monoculture—they tear off everything above ground. Schultz says the harvesters were developed with funds from tomato canneries concerned about producing large numbers of uniform tomatoes, not necessarily the greatest overall yields.

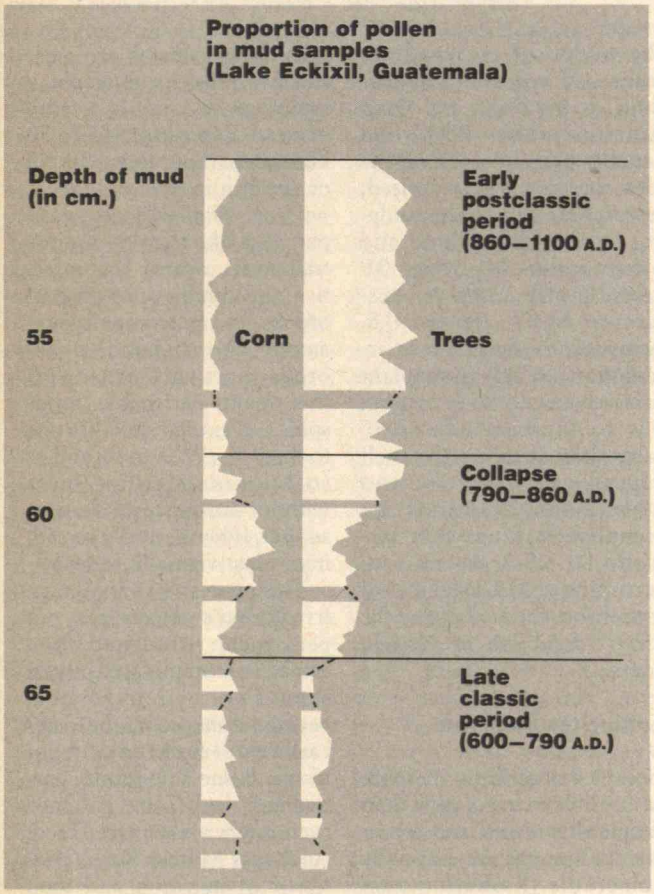
Farmers in developing countries who don't use machines obviously don't have to worry about their interfering with intercropping. Even in the United States, inter-

PHOTO: BRIAN SCHULTZ

cropping certain weeds in orchards can reduce the number of insects that attack the fruit trees, says Risch. At harvest time, the weeds can just be trampled. And intercropping may be practical for labor-intensive vegetable crops.

U.S. researchers are now trying to tailor polycultures to mechanization. For example, Donald Whigham of Ohio State University says that farmers can alternate corn and soybeans in four- or six-row strips and still use large machinery. In Iowa and Nebraska farmers have used this method to increase corn yields by 10 to 30 percent, says Whigham, while maintaining soybean yields and controlling pests.

Like farm machinery, today's herbicides were developed for monocultures, and they may kill not only the weeds but one of the crop plants in a polyculture as well. For example, the herbicide Lasso, which controls weeds in soybean fields, cannot be used when intercropping soybeans with tomatoes, as it kills them. Monsanto is studying how best to grow polycultures that are compatible with existing herbicides. For example, both corn and soybeans can be safely treated with Lasso. And Monsanto and other major U.S. agricultural companies are developing new herbicides specifically suited to polycultures.—*Peter Downs* □



Agriculture: Learning from the Past

More than 1,000 years ago, the powerful Mayan civilization of Central America collapsed, plunging the region into economic and political turmoil. The cause of the collapse is still a topic of fierce debate, but archeologists have uncovered evidence pointing to a series of untimely changes in agricultural policy.

"Because of internal stresses, the Mayan elite basically left agricultural policy up to the peasants, who started to plant only one type of crop—corn," theorizes Fred Wiseman, principal research scientist at the Center for Materials Research in Archeology and Ethnology at M.I.T. "Intense reliance on a single crop destroyed the topsoil and caused erosion. That in turn led to a famine so severe that within a generation, 90 percent of the Mayan population disappeared—either died or moved away. It was one of the most awful events in human history."

The Pollen Proof

Wiseman bases his theory on an analysis of pollen grains taken from samples of mud near Mayan ruins in the Yucatan region of Mexico, the northern lowlands of Guatemala, and Belize. The different strata of mud correspond to different time periods, ranging from the early classic period (beginning in 250 A.D.) through the collapse (around 800 A.D.) and on to the early postclassic period, which lasted until the Spanish conquest.

When the mud samples were brought back to the laboratory and treated with acids and caustic soda, they yielded pollen grains. The researchers identified which grains came from trees, corn, and other vegetation such as that of abandoned fields. They determined which kind of vegetation was predominant during a particular period by figuring the percentage of each type of grain in the samples.

The results indicate that during the late classic period, when the Mayans built elaborate temples and seemed at the height of their powers, there was little forest vegetation and relatively low production of corn. Other crops such as manioc, sweet potatos, and avocados were probably being grown. However, right before the collapse, the pollen analysis shows a "big blast of corn production." But afterward production of corn as well as other crops dropped to almost nothing, and forest virtually took over the area.

Why would corn production have risen so dramatically just before the collapse? During the late classic period the Mayan civilization was

Pollen samples collected from the mud in lakes near Mayan temples tell the story of that civilization's collapse. Corn production was low until about 800 A.D. because other crops were probably being grown, but then corn production rose sharply. Archeologists believe that this reliance on a single crop severely depleted the soil. Thus, corn production fell almost to nothing, and forests took over formerly cultivated fields.

DIAGRAM: OMNIGRAPHICS

apparently hit by unknown stresses—a series of internal squabbles, outright warfare, or maybe even a massive hurricane. Perhaps the rulers thought their gods were abandoning them and needed to be placated. In any event, they began pulling laborers from the farms to build bigger and better temples.

The empire's centralized system of decision making fell prey to the same societal stresses. The Mayan elite ceased to tell the peasants what to plant, where to plant, and when to plant the crops needed to provide a stable food supply. Since the easiest crop to plant and harvest was corn, the peasants, decimated in number by the temple-building crusade, began slashing and burning the landscape to grow the corn. This intense monocropping destroyed the topsoil and led to erosion, resulting in widespread famine.

An Unbalanced Economy

Today, in the same areas of Central America, peasants commonly use a slash-and-burn technique to clear the fields. The farmers then plant corn, beans, and occasionally squash as single crops for their own subsistence. Large landowners also do monocropping, raising bananas, sugar, or coffee for export.

Wiseman suggests that peasant farmers return to polycropping to produce more food for domestic markets as well as their own consumption. Ironically, this sort of agriculture is already being practiced on a smaller scale by the women of Central America in their backyard (commonly known as dooryard) gardens. There, the woman of the household raises everything from herbs and plants with medicinal values to vegetables and fruit trees. "If you go into the villages, you see what looks like a rain forest; that's the dooryard garden," Wiseman says.

In this sense, crops seem to be gender-linked. "I've heard local farmers say that polycropping is women's work," Wiseman says. To avoid conflict with these longstanding biases, he suggests that Central American governments encourage larger-scale polycropping by women. "Before the collapse of the Mayan civilization, women were intimately associated with farming," he notes. "Giving women a larger role in food production today would improve the agricultural system and give them back their former status in society."—*Alison Bass* □

Ordinary onions stored for six months in a warehouse were damaged by sprouting, but irradiated onions were not. Similarly, irradiated strawberries refrigerated for two weeks stayed fresh, but nonirradiated strawberries spoiled.

Bringing Irradiated Food to Market

When concern arose early this year about the carcinogenic pesticide EDB, Health and Human Services Secretary Margaret Heckler stepped forward to propose an alternative, at least for some uses—irradiation. Instead of fumigating fruits and vegetables with EDB, producers could apply low levels of ionizing radiation—gamma rays, x-rays, or electron beams—to kill insects, Heckler said. The food itself would not become radioactive, and Heckler claimed that neither taste nor nutritional value would be impaired.

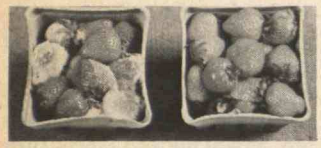
It was fortuitous that Heckler was able to announce the proposal to irradiate fruits and vegetables at that time, as the Food and Drug Administration (FDA) had actually been at work on the idea for three years. Indeed, researchers have been studying irradiation of those and other foods for some 30 years, largely under the auspices of M.I.T. and the U.S. Army. Enthusiasts favor irradiation not only to supplant toxic chemicals such as EDB, but to increase—in some cases dramatically—the shelf life of meats, tubers, and other foods. Irradiation accomplishes things that virtually no other process can, according to M.I.T.'s Edward Josephson, former head of the army's food lab in Natick, Mass.

Getting the Bugs Out

Complex organisms are more susceptible to irradiation than simple organisms, and reproductive systems are especially vulnerable. Radiation dosages for organisms are measured in rads; for example, a typical chest x-ray is a tenth of a rad. Exposures of 5 to 50 kilorads (a thousand rads) kill or sterilize insects and larvae on fruit. Similar doses make parasites like trichina (pork's trichinosis worm) less infective and inhibit sprouting of onions and potatoes, for example. Several hundred kilorads inactivate organisms that make perishable foods spoil and extend shelf life one to three weeks. A thousand or so kilorads sterilize meat without causing taste changes so that, if hermetically sealed, it will last virtually forever.

The process has its limits. Irradiation's effects are not permanent: irradiated food can be recontaminated, and it should not be reirradiated, because doing so might foster radiation-resistant organisms. Some soft foods, particularly fruits, are softened even further when irradiated. And, says Marcus Karel, professor of nutrition and food

PHOTOS: EDWARD JOSEPHSON



science at M.I.T., "There is no hope that milk will ever be preserved by irradiation." Exposure affects sulfur bonds and makes the milk taste bad. Irradiation has similar effects on other foods.

However, the major problem with irradiation lies in the complex array of radiolytic products (RPs) produced in food. Some of these RPs help kill or disable undesirable organisms. When radiation strikes molecules in food, some hydrogen or hydroxide ions are separated, leaving the molecule in a highly reactive state. This kind of RP, known as "a free radical," is short-lived and therefore does not pose a danger to humans. However, alone or combined into molecules such as hydrogen peroxide, the numerous free radicals make it difficult for organisms to pick up food, respire, and metabolize, so they are either suffocated or injured, says Josephson.

Other RPs are also formed during irradiation. Most have been identified as constituents of unirradiated foods. However, some "unique radiolytic products" (URPs) have not yet been identified, says Sanford Miller, director of the FDA's Center for Food Safety and Applied Nutrition. Critics of irradiation fear that these URPs might prove harmful.

Gauging Risks

Unfortunately, their concerns cannot be resolved by animal feeding studies. To determine whether a substance is harmful, animals must be given much higher dosages than humans would consume, and that simply isn't possible in the case of whole foods. "How much coleslaw can you feed an animal?" Miller asks rhetorically.

Instead, FDA scientists have followed another line of reasoning in assessing URPs. From a knowledge of radiation chemistry and the constituents of selected foods, the FDA estimates that 100 kilorads of irradiation produces approximately 30 parts per million of RPs. The FDA estimates that 90 percent of these RPs occur in unirradiated foods. So the critical unknown is the health effect of the remaining 3 parts per million—the URPs. The FDA argues that the level is low and that the URPs are "chemically similar" to natural food components. "The risk is trivial," says Miller.

Some critics disagree. Allan Greenberg of the Washington-based Public Citizen Health Research Group is unimpressed by what he sees as the FDA's overly theoretical analysis. "If you did that with any other food additive," he says, "you'd be crucified."

Even if the FDA allows producers to sell irradiated fruits and vegetables, consumers won't necessarily be buying them soon. Industry would first have to allay public fears about radiation. In fact, low-level irradiation of white potatoes (to inhibit sprouting) and of wheat (for disinfestation) has been legal since the mid-sixties, and the FDA approved higher levels for spices last year. (Their minimal contribution to diets eased concerns about URPs.) But no such irradiated foods have ever been sold commercially in the United States, says Miller: "For all the talk about irradiation, industry hasn't put a great deal of effort into it."—*David Kennedy and Sharon Moran* □

College Entrepreneurs

The tide is turning toward entrepreneurship on campus. After a decade and more of suspicion and ridicule, there's a rebirth of the spirit of enterprise among college students—a "megatrend," says Verne C. Harnish, executive director of the Association of Collegiate Entrepreneurs (ACE).

His phrase may be extravagant, but Harnish can be forgiven in light of the success of the ACE's first national conference, held at M.I.T. in April and attended by 225 students representing entrepreneurs' clubs from 55 colleges and universities. All the delegates had dreams of entrepreneurship, and almost all said the campus clubs they represent are flowering—the growth is "mind-boggling," said Robert King of Wichita State Unversity. That's especially true among engineering students. "Technology is where the world is going," said entrepreneur Edward Nieman of Northwestern.

Wichita State's entrepreneurs' club runs a popular lecture series on campus, and Stanford's club arranges an annual conference for over 1,000 would-be entrepreneurs in Silicon Valley who want to hear faculty and alumni talk about the problems and pleasures of profit making.

Despite resistance from the administration, undergraduates at the University of Kentucky persuaded the trustees to fund a venture-capital company that will, in turn, finance student businesses. Entrepreneurs are so busy at Babson College, near Boston, that they formed a licensing board to approve new student ventures to prevent cutthroat competition on campus.

Jimmy Enriquez of the University of Texas in Austin talked like a pro, maintaining that when you start a business you're likely to have tunnel vision. His school's entrepreneurs' club tries to foster a broader view, but its mission is mostly to tempt students to start businesses "while life is simple and you're not too risk-averse." As for Enriquez, "Five years from now I'm going to be running a big business."

The grandfather of all entrepreneurs' clubs is Harvard Student Agencies. After more than 25 years, it's a $1.6 million business that employs undergraduates and graduates in such diverse enterprises as publishing, travel, sales, consulting, film processing, and bartending. Harvard has two worries unique among those at the ACE con-

ILLUSTRATION: JON MCINTOSH

ference, said Lou Morsburger: preserving its tax-sheltered status despite all its income, and staying sensitive to new opportunities despite its size.

A different problem arose at Indiana University. When Barton Spencer tried to start a club there, he said, most campus entrepreneurs turned out to be "club-averse"—cherishing the independence that motivates entrepreneurs everywhere. Harnish admitted that "organizing entrepreneurs is a contradiction in terms," but at the conference his optimism seemed contagious.—*John Mattill* □

Managing Chaos

Successful high-technology companies operate at the knife-edge of a dilemma. They must have continuity, yet be flexible in developing new products and moving toward new markets. They must know their fields superlatively, yet be responsive to rapid change. This is what Modesto A. Maidique of Stanford and Robert H. Hayes of Harvard, writing in the *Sloan Management Review* (Winter 1984), call "the paradox of high-technology management."

After 20 years of study, Maidique and Hayes are convinced that you don't have to travel to Japan to find managements of high-technology companies who are skillfully resolving this paradox. Plenty of U.S. companies—IBM, Eastman Kodak, Hewlett-Packard, Boeing, Xerox, Analog Devices, and many more—are models of success. The two researchers think they have discovered why.

A basic characteristic of these companies is that they are focused; they confine their efforts to fields they know and can exploit. For example, IBM, Boeing, Intel, and Genentech concentrate, respectively, on computer products, commercial aircraft, integrated circuits, and genetic engineering. New products launched by such companies are closely related to earlier products. Research and development commitments are similarly focused and tend to be large—perhaps twice the industry's average.

Companies that wander from their strengths pay dearly, say Maidique and Hayes. In the mid-sixties RCA was an international leader in television, electronic components, communications, and radar, but then the company decided to diversify. By 1980 it was a conglomerate involved in businesses ranging from vehicle rentals to commercial broadcasting—with declining earnings and a $2.9 billion debt.

However, the successful high-technology company's sharpness of focus must be combined with the ability to make rapid shifts in products, and sometimes even "wrenching changes in direction." Until the fifties General Radio was a leader in electronic instruments, but the company failed to embrace major new technologies in its field such as microwaves and minicomputers. Now all that remains of the company's instruments line is a small area "where a handful of technicians assemble batches of old instruments."

The needed flexibility, say Maidique and Hayes, is possible only if top mangement has the confidence of its board and investors. And internally, "the energy and creativity of the whole organization must be tapped." Communication must be open between young employees, who are sometimes better innovators, and their elders, who have more experience. That means eliminating many of the conventional accoutrements of seniority that might undermine the firm's commonality of purpose. "The appearance of an executive dining room . . . is one of the clearest danger signals."

High-technology managers may deliberately loosen their companies' structure to promote innovation. Long known for its control over individual "product-customer centers" (PCCs), Texas Instruments recently made these into more autonomous units. "In the simplest terms, the PCC manager is to be an entrepreneur," says TI's president, Fred Bucy. However, other successful high-technology companies such as 3M are strengthening their management structures to "arrest snowballing diversity."

What's important, say Maidique and Hayes, is for management to behave "differently at different times in the evolutionary cycle of the firm. The successful high-technology firm *alternates* periods of consolidation and continuity with sharp reorientations that can lead to dramatic changes." To sum up, Maidique and Hayes turn to one of America's first innovators, Thomas Jefferson: "A little revolution now and then is a good thing."—*John Mattill*

Castles in the Air

Imagine looking down on a little landmark building in New York, carefully clad in its own style and sitting nicely on its green lawn," suggested William J. Conklin, an architect who is on the New York Landmarks Preservation Commission. "Floating above the landmark, in its own special heaven, like a piece of yellow legal paper, is an amorphous bulk of floor levels." Rather than building those extra floors allowed by the zoning, the owners can sell the "air rights" to owners of a nearby lot. Those neighbors can use the air rights to build a tower on their own lot with more floor area than the zoning would otherwise allow.

At a conference held in March by the *Brooklyn Law Review*, Conklin and others discussed whether such air-rights sales create a harmonious juxtaposition of small buildings and large ones, old and new—or whether they just create trouble.

A Turkish Bazaar

One trouble stems from the decidedly unharmonious dealings over air rights. For example, Norman Marcus,

counsel to the New York City Planning Commission, described the case of the office tower at One Park Avenue Plaza, a little west of Park Avenue. Needing to build more floor area than the zoning ordinarily allows, the developers sought air rights from the Racquet and Tennis Club on Park Avenue. The club decided the price wasn't right. However, the city gives zoning bonuses in exchange for certain amenities, so the developers persuaded the Planning Commission to grant them the extra floor area in return for including a 60-foot public galleria in the tower.

Not to be outmaneuvered, the club revealed plans to use its own air rights in a slim hotel that would obscure every window on the Park Avenue side of the proposed tower. Dutifully evenhanded, the Planning Commission began reviewing the plans for the hotel. But before the review was very far along, the developer and the club struck a deal for the air rights.

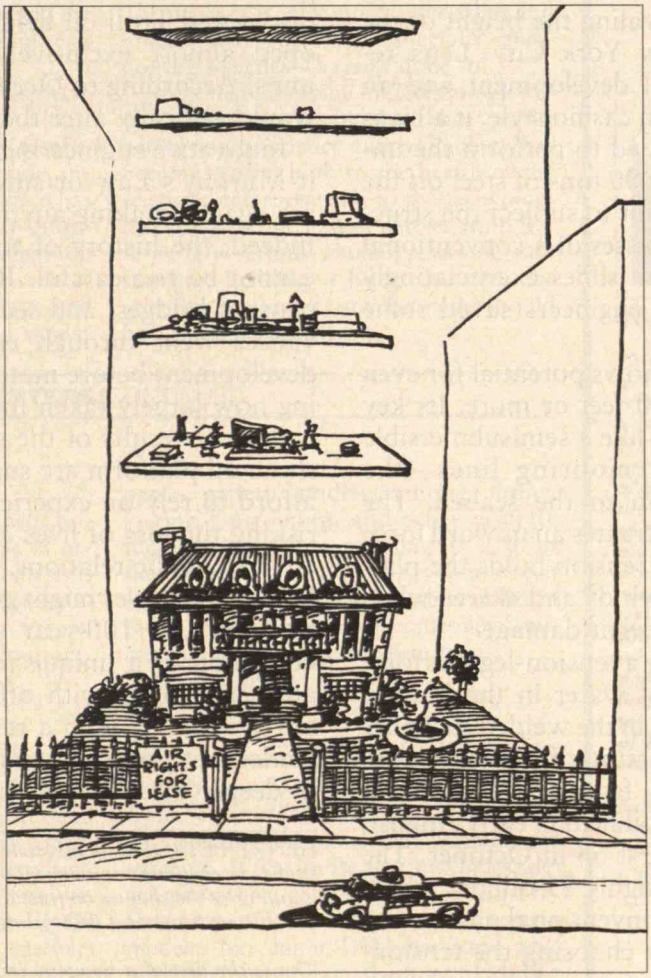
Air-rights transfers can sometimes amount to little more than "zoning for sale," said Curtis J. Berger, professor of real-estate law at Columbia Law School. "The city ordinances say, in effect: 'Developer, if you want to go beyond the zoning, then write a check—perhaps for air rights, perhaps for a pedestrian arcade, perhaps for the subway-improvements fund.' More and more, development in New York looks like a Turkish bazaar."

Donald H. Elliott, a lawyer who chaired the City Planning Commission from 1966 to 1973, disagreed. "Theoretically, if you read the zoning ordinance, every lot ought to be built at exactly the same density. But New York grew up in different times and different ways, and we ought to preserve that diversity. Air-rights transfer is one tool for doing it."

Long-Distance Sales

Any building's air rights can be sold to an adjacent lot on the same block in a "zoning lot merger." If a building is a landmark, its air rights can be sold to a more distant site in a "transfer of development rights" (TDR). Prevented by New York's landmarks preservation law from building a tower actually over Grand Central Terminal, the Penn Central Railroad instead sold the building's air rights to the Philip Morris headquarters on the next block. The air rights over the old Fulton Fish Market in lower Manhattan were sold to a kind of air-rights broker, a "TDR bank," which is in turn selling them to office towers in a nearby commercial district. The fish markets were preserved as a tourist attraction called South Street Seaport.

"I think we could transfer development rights a mile if we wanted," said Elliott. But doing so raises questions, as illustrated by Tudor City, a residential complex with two parks. In 1972 the city passed a special zoning law to preserve the parks, but allowed the owner to sell the air rights to sites more than a mile away in the midtown business district. "A neighbor blighted by the shadow of the extra-large building on the receiving lot is too far from the parks to benefit from them," said Marcus. A lower court ruled the zoning illegal partly for this reason. A higher court concurred but used a different argument, leaving the dilemma of how far air rights should be allowed to travel still unresolved.



So far, fewer than a dozen true TDRs have occurred, and the new structure has generally been built nearby. The architects must then ensure, as the law puts it, that the "transferred bulk" is "harmonious with the landmark." One can correlate the facade of the new structure with the old, lining up moldings and arcades. "But this approach is fraught with dangers," said Conklin. "Does a giant standing next to a dwarf look more harmonious if they both wear plaid shirts? Will this odd couple look more harmonious if one carefully correlates the garter lines of the giant with the belt line of the midget? Another approach is to lessen the negative impact of the new structure, for instance, keeping its loading dock away from the front door of the landmark.

"But there is a larger way of looking at the matter. Landmarks survived because of their quality. For architectural harmony in our times, little gem and big banal will forever create a discord, but little gem and big beauty just might be able to make beauty together."

—Jonathan Schlefer □

Oil From Troubled Waters

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sition. Each guyline is attached to a 200-ton weight on the seabed. Known as clump weights, they are built in segments that are joined together much like links in a bicycle chain. As waves or winds move the tower, the cable will lift segments in the clump weight and then set them down when the tension relaxes. Each cable can withstand a pull of several million pounds, and tests indicate that the deck could move as far as 40 feet off center without damaging the tower's pilings or breaking a guyline.

Exxon installed the first full-scale guyed tower, made by Brown & Root and known as Lena, in over 1,000 feet of water off the coast of Louisiana last June. From the seafloor to the top of the platform, Lena measures 1,320 feet, rivaling the height of the World Trade Center in New York City. Lena required 12 years of technical development and an investment of $750 million. In casino style, it all was risked in the 10 seconds needed to perform the untried technique of sliding 27,000 tons of steel off the side of a barge. By deciding not to subject the structure to the severe bending stresses of a conventional launch, in which the platform slides excruciatingly off the end of a barge, the engineers saved some 3,000 tons of steel.

The tension-leg platform shows potential for even greater depths, perhaps 6,000 feet or more. Its key feature is that it floats, much like a semisubmersible drilling rig. Tubular steel mooring lines—the "legs"—connect the platform to the seabed. The platform's natural buoyancy creates an upward force that keeps the legs taut. This tension holds the platform relatively still against winds and waves while letting it move enough to prevent damage.

Conoco is already building a tension-leg platform to be installed in 485 feet of water in the Hutton field of the North Sea. Cracks in the welded structure delayed the project, but company officials now say the platform will be towed from its shipyard in northeastern Scotland to the oil field in early August, and they hope to draw the first oil in October. The project is expected to cost roughly $1 billion, which makes it competitive with a conventional production platform at the same site. By choosing the tension-leg platform for this location, engineers hope to gain experience with installing and operating a radically new design in familiar ocean depths. Thus, they can work out any glitches before taking the technology into the more uncertain realm of deeper waters.

Another possibility is to put production facilities right on the seabed. These well-protected units would pump the oil through flowlines to shore, up to a storage tanker, or to a conventional platform serving a number of subsea units. Indeed, more than 200 subsea production systems are already in use in numerous offshore areas of the world. Most are in relatively shallow water, but last year Petrobras installed a system in 835 feet of water off Brazil. City Service/Occidental is now installing subsea units in 1,250 feet of water off the Philippines, and next year Chevron plans to place units in the Mediterranean off Spain in 2,500 feet of water. Oil company engineers are also evaluating whether the large, newly discovered Troll oil field off Norway can be developed almost exclusively with subsea production units. According to *Ocean Industry* magazine, "this would radically alter the industry."

Innovative engineering is never without risks. Call it Murphy's Law or simply inexperience, the odds are against making anything perfect on the first try. Indeed, the history of technology teaches that one cannot be too careful. Railroads, jet airliners, suspension bridges, and seemingly countless other advances went through early periods of disastrous development before maturing into feats of engineering now largely taken for granted.

But the results of the structural failure of an offshore oil platform are such that the industry cannot afford to rely on experience to advance its designs, risking the loss of lives and dollars, not to mention adverse public relations. Engineeers must try to anticipate whatever might go wrong, whether it be with resonance, a 100-year sea, metal fatigue, or the launching of a unique tower. So while giant steps are being taken with offshore platforms, designers are proceeding with a respectful caution for the relentless sea, in which mistakes become less tolerable as deeper oil fields are marked for exploitation.

HENRY PETROSKI is associate professor and director of graduate studies in civil and environmental engineering at Duke University. He is author of the chapter on fracture mechanics and fatigue in Dynamics of Offshore Structures *(Wiley-Interscience, 1984).*

This is the first of a two-part series on offshore oil. Part two, in the August/September issue, will focus on recent policy debates and new technology for tapping the Arctic's wealth.

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tists and engineers around the country participate in the Media Resource Service, which was set up by the Scientists' Institute for Public Information to connect journalists with people who may be able to answer their questions. But too many other authorities will refuse to talk to reporters, leaving the public at the mercy of publicity seekers and charlatans.

How do you convince these reluctant experts that—despite instances of bad reporting—it's worth their time and effort to talk to the press? It's not easy; many scientists and engineers, once burned, are twice shy. But I think public-relations officers, particularly at universities and companies, could do more to explain to their faculty and staff the importance of being accessible to the press. One good argument: If you don't talk to the press, someone else who perhaps knows less about your field will talk to them, and the reporting is bound to be worse because of your silence.

Some public-information offices have already attempted to bring staff and journalists together, with admirable results. Over the past two years, for example, the University of California-San Francisco has hosted a series of monthly Saturday-morning seminar-briefings for journalists on subjects in the life sciences. Other schools such as Michigan State, Ohio State, and Lehigh University have organized similar sessions. In addition to holding educational seminars, news officers should work to arrange periodic roundtable discussions between their scientific staff and local journalists. Such programs are inexpensive and, judging by the comments of participants, often quite successful in breaking down communication barriers. It's worth the expense of coffee and doughnuts or pretzels and beer to ensure that these gatherings include time for informal "schmoozing."

Of course, public-information departments do not have the authority nor the resources to bridge this gap singlehandedly. Scientists and engineers, on their own or through their professional organizations, must reach out to the media—not by hiring public-relations agents and bombarding journalists with self-serving press releases, but by inviting reporters and editors to open, give-and-take disussions. The mystery is why more universities and professional societies—especially engineering societies—haven't done so.

In the January issue of *Technology Review*, Bob Cowen pointed out that "public perception of science and technology has become crucial both to the health of the scientific enterprise and to the technological strength our nation derives from it." If we are serious about preserving that strength, building a bridge between the scientific community and the media should be a national priority. □

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rejected) even though the risk-benefit calculus dictates the opposite course of action. The danger of risk-benefit analysis is that its focus on a certain product or activity may mean that a safer product is excluded even before a more hazardous one.

Pioneer's Prerogative

In "Can Computerization Save U.S. Shoemakers" (*April, page 79*), Renée Loth incorrectly states that the computerized stitchers of United Shoe Machinery (USM) demand temperature-controlled environments and use massive amounts of power. USM supplies about 95 percent of the world's operating computerized stitchers because of the high quality of our product and its effective cost. Shoemaking encompasses pattern grading, cutting, fitting, lasting, bottoming, and other discrete functions as well as stitching. In each of the five major areas, USM has commercial equipment or trial models that utilize a range of programmable controllers, microcomputers, and microprocessors.

William Scanlon
Beverly, Mass.

Mr. Scanlon is president of Emhart Corp.'s Shoe Machinery Group, formerly USM. The author responds:

As I noted, USM pioneered computerized stitching. It was those first machines, developed over a decade ago, to which I referred in noting the inefficiencies of certain models. No doubt USM has kept pace with technological advances; I didn't mean to imply otherwise.

With an assist from batteries that he has previously charged, M.I.T. undergraduate Frank Scarabino pedals Monarch to a world speed record for human-powered aircraft. That achievement by students and recent graduates sparked a claim for a $30,000 prize.

Human-Powered *Monarch* Claims a World Speed Prize

Battling both the forces of gravity and friction and a determined West Coast challenge, a group of M.I.T. aeronautical students has claimed a much-publicized international prize for speed in human-powered flight.

Shortly after dawn on May 11, senior Frank Scarabino mounted the team's 74-pound aluminum, mylar, and styrofoam craft, the *Monarch*, at Hanscom Field in Bedford, Mass. For 7.5 minutes he pedaled in place to charge up the 20 nickel-cadmium batteries (1.2 ampere-hours each) that provide 25 percent of the *Monarch*'s power in flight.

Then he had 90 seconds according to the flight plan to reconfigure the plane—connect his pedals to the propeller instead of the generator and switch the generator into a motor that draws back from the battery the energy that's just been fed in.

That done, Scarabino took off, climbed quickly to the required altitude of eight feet, and pedaled the gangly craft around a triangular 1,500-meter course in 2 minutes, 49 seconds. The whole flight took 11 seconds less than the three minutes specified for the $30,000 award offered by British industrialist Henry Kremer.

Certification for the prize was no rubber-stamp procedure. The decision rested with Britain's Royal Aeronautical Society, which in turn relied on reports filed by two RAS members as official observers: Rene H. Miller, professor of aeronautics and astronautics at M.I.T., and Donald Fraser, vice-president for technical operations at Draper Laboratory. Last fall, the RAS turned down a claim for the speed prize from M.I.T.'s main rival, the California group headed by Paul MacCready that won the original Kremer Prize for demonstrating human-powered flight and a second award for pedaling over the English Channel. The grounds for rejection: the California team had partly charged its plane's batteries before the pilot started pedaling in place.

To overcome that objection, Scarabino charged up the batteries from zero voltage—thus putting some energy into the system that could not be withdrawn later.

The M.I.T. team had first learned of the new Kremer Prize from a casual conversation with MacCready more than a year ago. Thinking that its rivals were close to a second attempt, the *Monarch* team took a vow of secrecy last spring: their success was a complete surprise to almost everyone in Cambridge.

There seem to have been two factors in *Monarch*'s success:

☐ *Monarch*'s advanced avionics and electronics ensured best use of the energy available. The craft's variable-pitch propellor and associated control circuits—the kind of thing M.I.T. students are especially good at, said the *Monarch* team with smiles—continuously regulates the amount of current drawn from the batteries in flight. Without it, *Monarch* had frustrated its pilots last year by delivering less electrical energy whenever they pedaled harder in search of more power.

☐ Scarabino's two months of intensive training before the flight paid off. Experienced pilots say that *Monarch* makes very heavy demands on its pilot to simultaneously pedal, steer, and control the craft's attitude—"the hardest-workload airplane they've ever flown," says project co-leader John Langford.

But despite his pivotal role, the pilot was merely the point man for the flight. Backing him was a team of at least 15, headed by Langford and fellow-graduate-student Mark Drela, that put about $7,300—much of it their own money, a little of

M.I.T.'s—and 6,200 person-hours of work into the project in a little more than one year.

Scarabino had almost broken the three-minute barrier over the official course five days before the successful flight, missing the goal by only one-half second. When they discovered that *Monarch*'s batteries had plenty of energy left in them, the crew realized that it was all for real, that they had a good shot at the prize.

Now the team waits for fresh challenges. Kremer will give new prizes of $7,000 for human-powered planes that improve the *Monarch* record by increments of five percent. The crew has to wait a year after *Monarch*'s record is certified to go for that goal—unless another team beats its time before then. And stemming suspicions that the project is a venture without purpose beyond winning prizes, the Office of Naval Research and the National Aeronautics and Space Administration have both shown interest in applying the aerodynamics of low-speed flight to problems with aircraft that fly at very low and very high altitudes. □

Crime from the Inside

How do criminals work? To learn the answer, present people—criminals and the rest of us—with temptations, and wire them for sound so they can give you their play-by-play responses.

That in a nutshell is the research plan devised by Professors John S. Carroll of M.I.T. and Frances M. Weaver of Loyola University of Chicago. They asked 17 "expert" shoplifters and 17 "novices" to "think aloud" as they walked through Chicago department stores seeking opportunities to help themselves to merchandise. The shoplifters described their temptations, the strategies they considered for realizing them, and—most important of all—the deterrents.

The deterrents, it turned out, were mostly people—sales personnel. Mirrors, cameras, and security systems were by comparison ineffective. "Store personnel are dynamic," say Carroll and Weaver; "they can change their behavior to interfere with shoplifters' strategies."

The conclusions of the research:

□ Alert store personnel are the "front line" of defense against shoplifters.

□ This "think aloud" strategy may be a significant new way to understand crime and how to deter it. □

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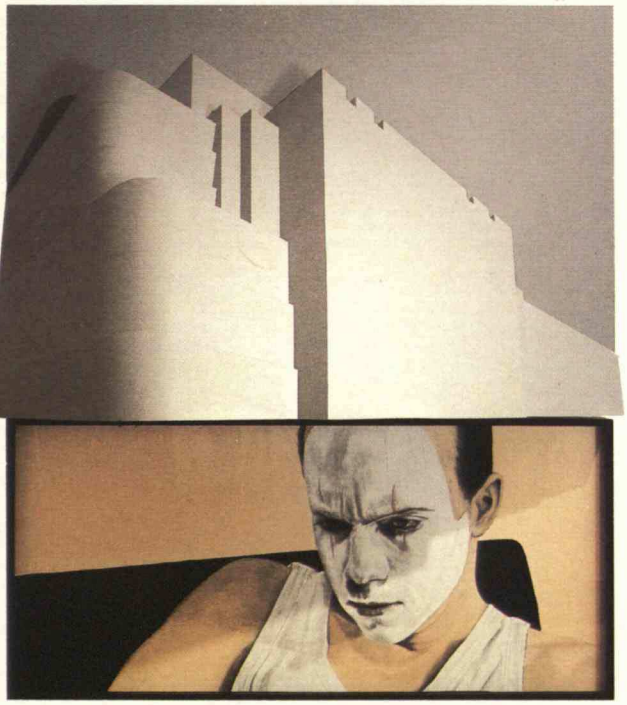

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